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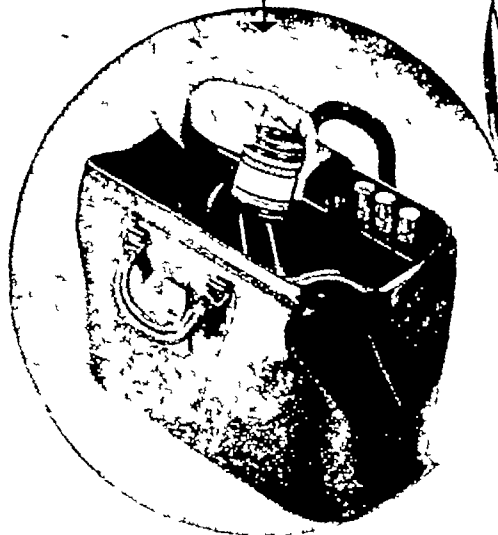
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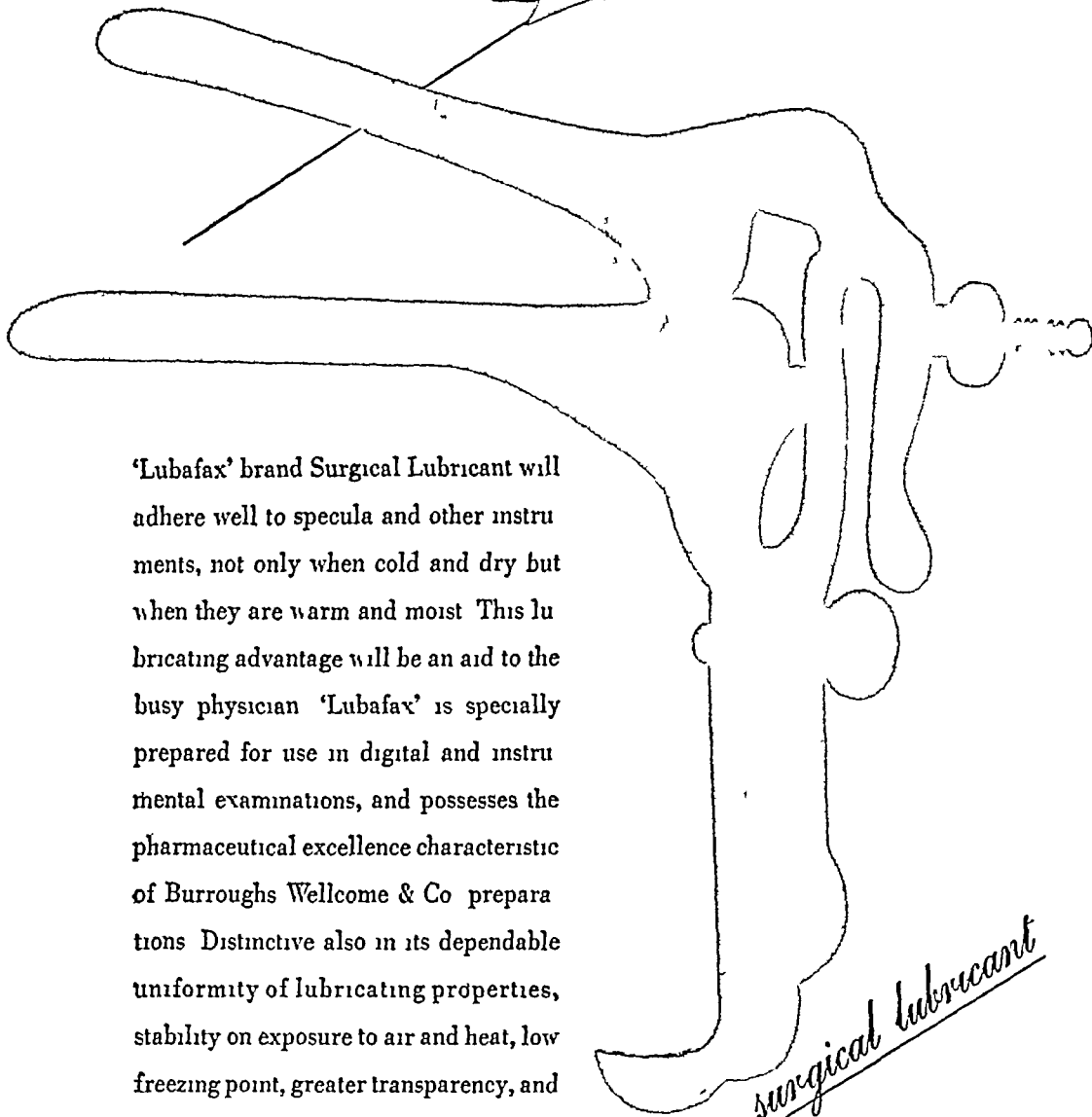
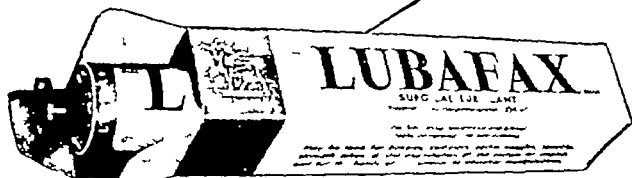
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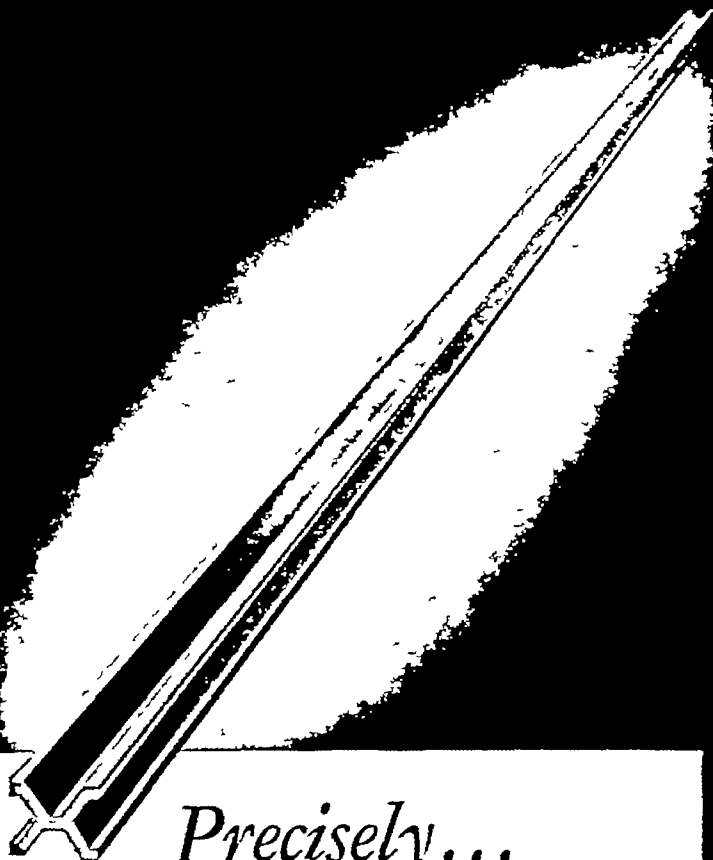
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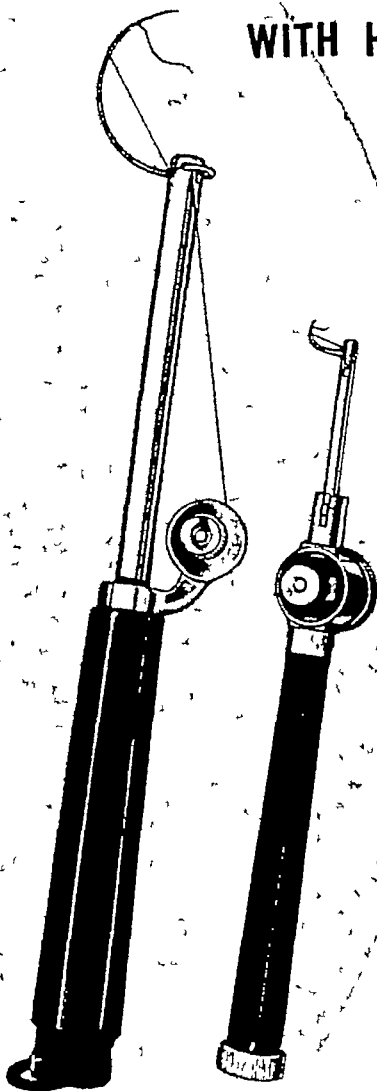


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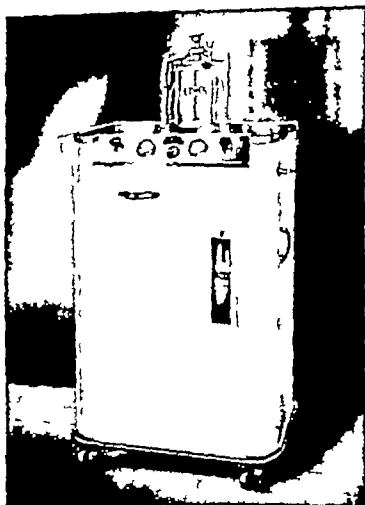
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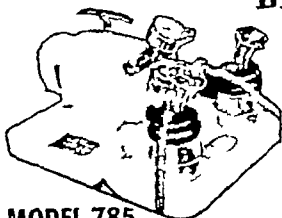


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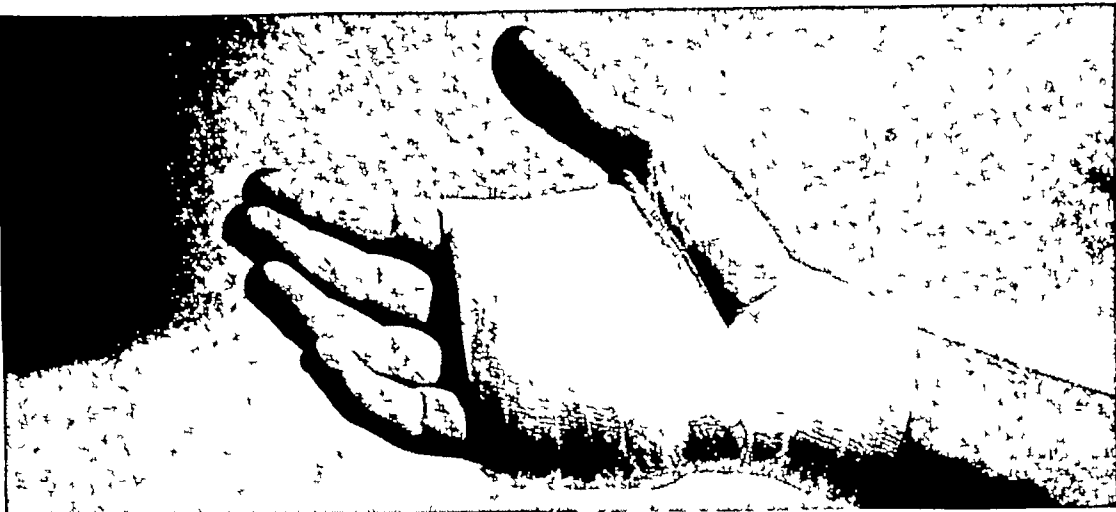
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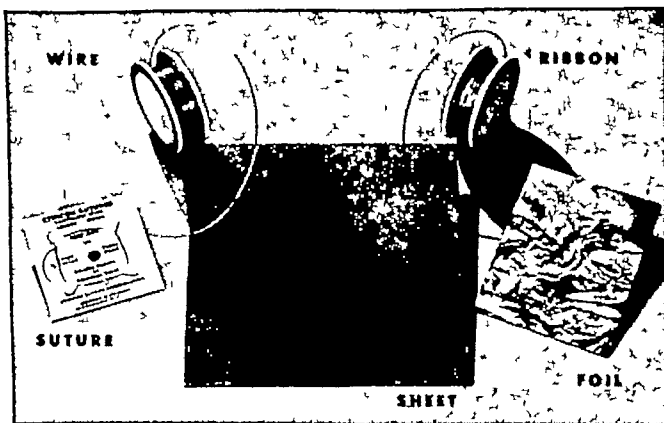
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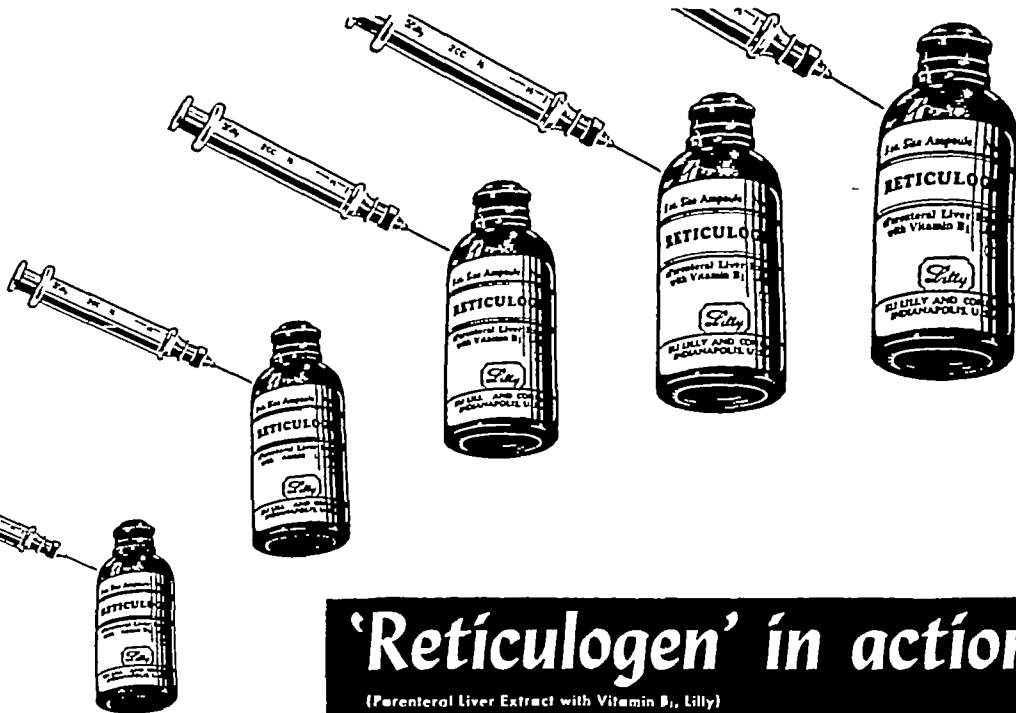
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SURGERY

VOL 20

JULY, 1946

No 1

Original Communications

Society of University Surgeons

TECHNICAL CONSIDERATIONS IN SURGICAL THERAPY FOR COARCTATION OF THE AORTA

ROBERT E. GROSS, M.D., BOSTON, MASS

(From the Surgical Service of the Children's Hospital and the Department of Surgery of the Harvard Medical School)

IN THE "adult type" of coarctation there is a narrowing or complete obstruction of the aorta at or near the ductus arteriosus or its obliterated remnant. Individuals with this abnormality have a variable prognosis, some survive for a surprisingly long time and have relatively mild symptoms, but most of them have a life span which is far short of the normal expectancy. They may have complaints which arise directly from the arterial obstruction, or they may have a serious disorder from one of its complications. These include (1) aneurysmal dilatation of the aorta, particularly above the constriction, (2) rupture of the aorta, (3) formation of a dissecting aneurysm, (4) superimposed *Streptococcus viridans* infection, (5) development of high blood pressure in the upper part of the body, with all of the attendant dangers of the hypertensive state. In the future it is probable that local bacterial infections can be efficiently combated in many instances by modern methods of chemotherapy. However, the other complications have little promise of relief, and because of this state of affairs there is a real impetus for finding ways in which the coarctation of the aorta might be corrected.

Our observations in the experimental laboratory^a indicate that it is technically possible to remove a segment of the thoracic aorta and to reconstruct the vessel by end-to-end anastomosis. With this background, five human patients have been operated upon in this clinic for coarctation of the aorta with very promising results. Additional evidence that such operations can be successful in man is brought forth by the report of Crafoord and Nylin.⁴ Although experience in this field of surgery is still limited, it appears that removal of an

^aPresented at the annual meeting of the Society of University Surgeons, New York N. Y., Feb. 7-9, 1946.

anomalous aortic segment can be accomplished without too great a risk and that hypertension in the upper part of the body can be relieved. These procedures are new and will possibly undergo modifications as additional information is gained. However, I would like to discuss some of the technical details which have been formulated or have been found to be of value during such operations on human subjects.

Anesthesia—Anesthesia with ether should be satisfactory, but cyclopropane would seem to be preferable—and was used in all of our cases. It is necessary to have some sort of a closed system to administer the anesthetic so that the intrapulmonary pressure can be controlled at will. However, an intratracheal tube is not essential, and I believe that it is better to omit it. A closed system was maintained in our patients by merely using a tightly fitting face mask. With such arrangements, anesthesia, even though quite prolonged, was completely satisfactory and could not conceivably be improved.

Vein Cannula—It is now a common practice to prepare for major surgical undertakings by inserting a needle into a vein of an extremity prior to operation to facilitate the administration of fluids and blood during and after the procedure. Certainly, for operations upon the aorta, this precaution will add greatly to the operator's peace of mind because he is assured that blood can be given in an instant if conditions demand it. Bleeding from the aorta or its anastomosis should be minimal or nil, but the great vascularity of the chest wall will sometimes lead to a serious loss of blood while the thorax is being opened and it may be necessary to compensate for this. A sharp needle may not be wholly satisfactory because it can be disturbed at a crucial moment and can penetrate the back wall of the vein, thus being thrown out of commission just when it is needed most. It is better to cut down on a vein, preferably of the ankle, to insert a blunt cannula of moderate size (No. 14 or 15) which can be tied into the vessel, and which can be relied upon to function perfectly for a period of many hours. Attached to this needle should be an infusion apparatus, the tubing of which contains a three-day stopcock, arranged in such a way that blood will pass through it slowly from a suspended bottle, or else a syringe can be attached to its sidearm for pumping blood through the system under pressure if this should be required.

Operative Approach—Much can be said in favor of an anterior or an anterolateral thoracic approach to the aortic arch and the first part of the descending aorta. With this avenue the thorax can be opened quickly, the division of chest muscles is minimal, and the resulting exposure is wide. The closure of such a wound is relatively easy and the postoperative discomfort to the patient is distinctly less than is the case with a posterior incision. Much of the experimental work on dogs was done through an anterior opening, but it soon became obvious that conditions were not optimum for manipulating and rotating the aorta to expedite suture of its ends. In contrast, a posterior incision will allow clamps to be placed on the aorta in such a way that they can be rotated forward and thus provide room for the operator to sew the back wall of the aorta, subsequently the clamps (and aorta) can be turned backward so that the anterior edges of the vessel can be stitched. This single and important fact

led to the adoption of a posterior approach in all of the more recent animal experiments and in each of the human operations. Without question, the aortic arch and the first part of the descending aorta can be clearly viewed through an anterior chest wound, but in order to work effectively upon this vessel, to free it from its bed with safety, to mobilize it, to remove the narrowed segment, and to suture its free ends, a posterior thoracic approach is much superior.

Opening of the Chest—The incision must be liberal. It runs along the medial and inferior borders of the left scapula in a downward and outward direction, extending from the level of the second dorsal vertebra superiorly to the midaxillary or anterior-axillary line inferiorly. That portion of the trapezius which presents beneath this cutaneous opening is cut across. The broad belly of the latissimus dorsi muscle is completely transected, at right angles to the direction of its fibers. The rhomboideus major and minor muscles are divided near their attachments to the medial border of the scapula. The scapula can then be displaced upward and outward so that the underlying bony cage of the thorax is brought into view. The fourth rib is removed subperiosteally from its midaxillary zone around to its tubercle. From the third, fifth, and sixth ribs a segment, 3 to 4 cm. long, is cut out from the rib angle well down to the tubercle. The pleural cavity is now entered by incision throughout the bed of the fourth rib. At its medial end this incision is connected with a vertical one running up through the previously exposed bed of the third rib and similarly running downward through the fifth and sixth rib beds and intercostal muscles. When a self-retaining retractor is inserted, an adequate exposure of the interior of the chest and the operative field can be obtained.

Opening of the thorax may entail more difficulty than had been anticipated, because of the extreme vascularity of the various structures. Pathologists have often commented upon the large collateral channels which are associated with aortic obstruction, and clinicians have frequently described the pulsating arteries in the soft tissues of the back. The surgeon must be cognizant of these sizable vessels, indeed, he cannot ignore them. The vascularity of the region is so great that considerable time is consumed in clamping, tying, and suturing bleeding points to obtain proper hemostasis. Blood loss may be great, and it is important to cover this adequately by transfusion so that the patient is kept in a stable condition.

Freeing of the Aorta—The aorta is exposed by longitudinal incision of its overlying parietal pleura from the mid-thoracic area well up over the aortic arch and over the left subclavian artery. With little difficulty, this covering is peeled posteriorly and anteriorly. It is well to keep the dissection fairly close to the aorta and to leave but little areolar and fatty tissue on the vessel. The narrowed portion of the aorta can be readily seen and palpated. The external diameter at this level may be a poor indication of the size of the lumen, but squeezing the vessel between the thumb and forefinger will give some idea of the dimensions of its internal opening. Sometimes the vessel is deeply notched and a high degree of obstruction is readily discernible. In other instances the external indentation is mild and is seemingly not far from normal, still there can be such a great thickening of the vessel wall at this site that the lumen of the

aorta is no more than 1 or 2 mm in diameter, indeed, it may be completely blocked. Coarctation occurs at a variable distance from the left subclavian artery. In some subjects it is just below the origin of this artery, whereas in others it may be as much as 2 or 3 cm beyond it. Obviously, the lower constrictions are more amenable to treatment, but a high position of the coarctation, just beyond the left subclavian artery, does not militate against surgical removal of the narrowed segment, as was shown by our fifth patient.

A considerable section of the aorta, as well as the distal part of the arch, must be raised from its bed to facilitate the subsequent steps. This implies that certain vessels shall be severed to free the aorta from surrounding structures. Just below the coarctation at least two sets of intercostal arteries should be doubly ligated and divided. While these arteries may be enlarged to a diameter of 5 or 6 mm, they are apt to be quite thin and should be handled accordingly. Great caution must be exercised to avoid shearing off an intercostal artery as it leaves the aorta, a region of great anatomic weakness. Such an accident gives rise to bleeding which is very difficult to control, and the seepage of blood through the adventitia greatly obscures the field and hampers the dissection. Such mishaps were at times encountered in dogs, they were completely avoided in the human beings by exceedingly careful techniques. It might be necessary to divide one or two sets of intercostal arteries above the coarctation, the existence of such vessels appears to be a variable finding. (Apparently Crafoord has not divided intercostal arteries, but has temporarily clamped them. I believe it is much better to sever them since this permits mobilization of the aorta and it likewise keeps unnecessary clamps out of the field.)

On the anterior surface of the aorta, one or two bronchial arteries will almost certainly require division, depending upon the level at which these arise from the aorta. These vessels are small and can be cut with impunity.

The ligamentum arteriosum (or ductus arteriosus) must then be cut, and when this is done the operator is immediately conscious of a high degree of mobility which has been gained for the aortic segment. Six or seven centimeters of the aorta can then be drawn up into the field. This freed portion is most easily handled by passing linen tape around it. Any remaining bands of areolar tissue which connect it to its bed are cut away. The dissection is carried well up behind the distal third of the aortic arch and up for several centimeters behind the left subclavian artery.

Structures to Avoid—Within the mediastinum are two anatomic structures which must be kept in mind and constantly avoided. The first of these is the left vagus nerve and the recurrent laryngeal nerve which arises from it. This branch courses below and around the ligamentum arteriosum and then upward on the posteromedial surface of the aortic arch. These nerves can be easily identified after the parietal pleura is opened, they can be peeled off the aorta and the ligamentum arteriosum in such a way that they are left undisturbed and uninjured.

Likewise, great care must be exercised to leave the thoracic duct undisturbed. This lymphatic channel lies against the vertebral column and should be found between the right and left intercostal arteries just after they leave the

aorta In some human beings the duct stands out clearly and can be readily identified In others, it is small or is obscured by overlying fat so that it is difficult to find Possibly the vessel could be seen more clearly if any appropriate dye were fed before operation or were injected into the lower part of the body so that it appears in the duct Whether or not the duct is seen, it can be saved from injury by keeping the posterior and medial dissection very close to the aorta itself and not letting the instruments get into the deeper tissues which contain the duct

Clamps for Aorta—A pair of clamps must be provided for maintaining hemostasis during the subsequent period when the aorta will be opened It is also highly desirable to have these clamps in such a form that they can be used to manipulate the aorta In laboratory work it was found that full-lengths, Kelly clamps, Kocher clamps, etc., would grasp the aorta tightly, but the rigid jaws were apt to traumatize the vessel to a disturbing degree Bethune clamps gave good hemostasis, but they wrinkled the aorta too much A wide variety of instruments were tried, but for one reason or another they were all discarded The best results were obtained by revamping a pair of Moynihan, straight intestinal clamps and using them without rubbers The jaws were cut off to a length of 5.5 cm, the tips were fitted with an interlocking peg so that the two jaws could not wiggle sideways from one another when the clamp was closed With such an instrument, considerable pressure can be exerted on a large vessel, and yet the jaws possess sufficient resiliency so that there is very little crushing effect The clamp cannot slip sideways because the longitudinal slits in the jaws grasp the adventitia securely Furthermore, endwise slipping of the clamp is guarded against by cross-marks filed on its inner surfaces The instrument will accommodate vessels varying in size from the smallest to the largest which might be expected

Suture Material—Obviously, the suture material must be of a nonabsorbable type Silk was employed in all of the experiments with animals and with human beings An interwoven variety is far superior to a twisted one because it has higher tensile strength, smaller caliber, and no tendency to fray out Deknatel (00000) is an appropriate form and size This is carried on an atraumatic needle so that an exceedingly small hole is made when the aorta is pierced While a slightly curved needle has some advantages, a straight one about 15 mm long is preferable

Excision of Aortic Segment—The two clamps are placed upon the aorta in such a way that a portion $1\frac{1}{2}$ or 2 cm long can be cut out and discarded In addition, sufficient room (almost 1 cm) must be left inside of either clamp to provide a cuff which can be used for anastomosing the remaining vessel ends When the aorta has been divided, these cuffs immediately shrink, they may become so short that it is very difficult to sew them in an accurate fashion Hence it is imperative, when affixing the clamps, to make due allowance for shrinkage of the vessel ends which will invariably take place when the aorta is transected

While the aorta is being severed, one must constantly keep in mind the sizes of the upper and lower orifices which are being produced These must have ap-

proximately the same dimensions to permit proper anastomosis. In order to accomplish this, it might be necessary to cut the upper or the lower part on a little slant to produce an end of appropriate size.

The segments of aorta which were removed from the five human patients showed extreme degrees of obstruction. Four of the specimens possessed a lumen no more than 2 to 2.5 mm. in diameter, while the fifth had a complete diaphragm and no opening at all.

Method of Aortic Anastomosis—For aortic anastomoses, Crafoord and Nylin have employed a technique which has been generally used for vascular suture for many years. With this Carrel method of triangulation, the ends of the vessel are brought together by three interrupted stitches placed at equidistant points around the circumference of the vessel, and then each of these limbs sewed with a running stitch. The description would seem to imply that the ends of the aorta can be held together with the three interrupted sutures while the vessel is being repaired. While this may be true, it is well to emphasize that when the aorta is transected, its ends separate from one another in a very distressing way. Hence, any attempt to overcome this great tension by holding the aortic ends together with a few interrupted stitches would seem to be fraught with dangers and pitfalls. Instead it has been my plan to have a well-instructed first assistant manipulate the two clamps, and to hold them so that they are pushed toward one another, a movement which brings the ends of the aorta together and removes all tension from the suture line while the anastomosis is being performed.

In the laboratory, experiments have been carried out with various methods of aortic suture and it is felt that the usual type of Carrel stitch, whereby the vessel ends are butted together with an over-and-over stitch (including all layers of the wall), will often give a successful anastomosis, but that it cannot be relied upon to accomplish this task uniformly. Without question, the method par excellence is that in which a continuous, mattress type of stitch includes all layers and brings intima to intima, turning the vessel ends outward. This technique was used in all of our cases, the procedure has been described and illustrated in a previous communication.⁶ The thread must be drawn up with appropriate tension and must not be relaxed while a subsequent stitch is being taken. It is well to delegate the holding of the thread to a second assistant whose attention is not deflected by any other duty at the moment. The most difficult part of the anastomosis is on the posterior surface of the aorta, hence the stitching should be started here and then continued around on the anterior wall. The first assistant can rotate the clamps to give the best exposure of the posterior or the anterior wall of the aorta as the operator requires. After the anastomosis is completed the lower clamp is removed or temporarily loosened. With this maneuver some blood will flow back into the area under a relatively low pressure and the line of anastomosis can be quickly tested. In one or two points there may be pinhole openings, but these can be closed with a few interrupted stitches. If the original stitching has been properly performed, there is little or no oozing. It is highly important to emphasize that the use of packs, fibrin foam

with thrombin, or other anticoagulants is not needed for buttressing the suture line if the anastomosis has been done accurately. In none of the five human cases was it necessary to employ any such secondary methods for hemostasis.

Prevention of Cardiac Collapse—From some of our experimental work, and from a disastrous outcome in one case, it is evident that a quick removal of the last aortic clamp may impose a momentary but serious burden on the cardiovascular apparatus. The sudden opening up of an enormous vascular bed in the lower part of the body makes great demands upon the heart. The cause of death in the first patient has been loosely described as "cardiac collapse," since the exact mechanism of failure is not known. Presumably, it was a form of "shock," because blood flowed rapidly into the depleted system in the lower two-thirds of the body, pooled there, and did not return quickly enough to supply the heart with a circulating medium. Having these thoughts in mind, certain measures were taken in the last four patients to prevent cardiac failure at this stage by (1) removing the remaining (upper) aortic clamp gradually over a period of five or six minutes so that the rush of blood into the lower aortic segment would be retarded somewhat, (2) tipping the patient into a mild Trendelenburg position to facilitate the return of blood to the heart, and (3) quickly injecting 150 to 250 c.c. of blood (under pressure) into the ankle vein cannula to augment the circulating fluid. With such precautions, there was very little change in the rate or amplitude of the heartbeat, and the readjustments in the circulation were completed without the slightest apprehension.

Closure of the Chest—Of primary consideration in the thoracic closure is the avoidance of large vessels in the chest wall, the puncture of which will allow bleeding into the pleural cavity. Such hemorrhage is apt to be particularly troublesome in the vertical part of the T-shaped wound (that part parallel to the spine). Hence, it is well to start the closure here so that the interior of the chest can be viewed from time to time to make certain that blood is not running into it. If this occurs, additional sutures can be appropriately placed to obtain hemostasis. The lateral part of the wound is now closed by approximating the edges of the bed of the fourth rib. If the needle is kept well within this bed, and not allowed to go out into the adjacent intercostal muscles, bleeding is avoided or kept to a minimum. The superficial muscles are suitably repaired.

The lung can be expanded by increasing the pressure in the anesthesia machine, but I am convinced that there is less postoperative disturbance in the lung if it is expanded by sucking out all fluid and air from the pleural cavity. This can be done quickly and effectually by inserting a large catheter into the pleural cavity, aspirating through it, and then withdrawing it just before the skin is closed.

Postoperative Care—There is little to add regarding the postoperative care of these individuals, except to state that it can be made extremely simple. Oxygen tents are unnecessary if the lung has been adequately expanded at the termination of operation.

In the four surviving patients, the wound healed per primam. Because of the length of the operative procedure, and because of the possible accumulation

of sanguineous fluid within the pleural cavity which would be a good culture medium, it was deemed advisable to prescribe penicillin and sulfadiazine for five or six days after operation. These drugs are probably unnecessary and good results can undoubtedly be obtained without them, yet it appears to be expedient to employ them in the immediate postoperative period.

Posterior chest wounds may give a great deal of pain if rib ends are improperly mobilized and are allowed to rub together during respiratory movements. Conversely, postoperative pain can be kept at a minimum and sedation can be reduced if a segment of rib is always removed so that the ends of bone cannot touch each other during the postoperative period. The ribs will regenerate from the periosteum which is left.

It is not necessary to administer dicoumarin or heparin to prevent local thrombosis. If the aorta is not damaged by instruments, and if a proper anastomosis has been performed, the danger of regional thrombosis is insignificant.

It may be necessary to withdraw fluid from the left pleural cavity during the postoperative period. In two of our patients the chest was aspirated once during the first postoperative week and a considerable amount of thin hemorrhagic fluid was taken away. There was no reason to suspect leakage from the aorta since the anastomosis lines were left completely dry at the time of operation. Such an accumulation of pleural fluid was almost certainly due to oozing from the thoracic wall.

SUMMARY

Coarctation of the aorta is a congenital abnormality which can be corrected by direct surgical attack on the lesion. The narrowed or completely obstructed segment can be excised, and the remaining portions of the aorta can be brought together by an end-to-end anastomosis. Five patients have been thus treated, the first died of cardiac failure during operation, while the other four have made very satisfactory recoveries. Laboratory experimentation which led to development of this technique, plus the experience which has been gained from the human cases form the bases for the various remarks which are listed here as technical considerations in surgical therapy for coarctation of the aorta.

REFERENCES

- 1 Abbott, M. E. Atlas of Congenital Cardiac Disease, New York, 1936, American Heart Association.
- 2 Blackford, L. M. Coarctation of the Aorta, Arch. Int. Med. 41: 702, 1928.
- 3 Clermont, G. Suture Latérale et Circulaire des veines, Presse méd. 9: 229, 1901.
- 4 Crafoord, C., and Nylin, G. Congenital Coarctation of the Aorta and Its Surgical Treatment, J. Thoracic Surg. 14: 347, 1945.
- 5 Dorrance, G. M. An Experimental Study of Suture of Arteries With a Description of a New Suture, Ann. Surg. 46: 409, 1906.
- 6 Gross, R. E., and Hufnagel, C. A. Coarctation of the Aorta, Experimental Studies Regarding Its Surgical Correction, New England J. Med. 233: 287, 1945.
- 7 Gross, R. E. Surgical Correction for Coarctation of the Aorta, SURGERY 18: 673, 1945.

ARTERIOVENOUS FISTULAS AND ARTERIAL ANEURYSMS IN MILITARY PERSONNEL

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AS IS well known, arteriovenous fistulas and arterial aneurysms result from trauma, congenital anomalies, and infection, and arterial aneurysms from arterial disease as well. The congenital and traumatic aneurysms and fistulas are generally amenable to operative treatment. On the other hand, surgery is less uniformly applicable in the cure of aneurysms resulting from arterial disease for two reasons: first, the preponderance of these lesions in the aorta which can rarely be ligated without disastrous consequences or successfully repaired and, second, the frequently precarious state of the collateral circulation in limbs in which such aneurysms exist, which is due to the associated obliterative arterial changes. Congenital aneurysms and fistulas are relatively rare, and traumatic aneurysms and fistulas occur commonly only in time of war. Because of these considerations it has not often been possible for any individual or group to treat large numbers of these lesions and, consequently, reports concerning their surgical management generally deal with single cases or small series of cases.

During the recent war the staffs of the three Vascular Centers established by the Surgeon General have studied and cared for large numbers of soldiers with aneurysms and arteriovenous fistulas. We have had opportunity to treat many such patients at the Vascular Center at the Mayo General Hospital and to study others who were operated upon elsewhere. It is believed that a brief general discussion of this experience and of some of the problems encountered may prove worth while. No attempt will be made in this report to present in detail certain specific problems which can be discussed more profitably in separate reports. In addition, for the further sake of brevity, in this communication will be omitted references to the large body of constructive clinical and experimental studies which have been recorded in the literature and which have, throughout the years, rendered the surgical treatment of aneurysms and fistulas progressively safer and more successful.

CLINICAL MATERIAL

This study comprises 364 arteriovenous fistulas and arterial aneurysms which occurred in 351 individuals. There were 245 arteriovenous fistulas and 119 aneurysms. The material consists of three groups: first, 206 arteriovenous fistulas and 82 arterial aneurysms which we treated by operation at the Mayo

General Hospital,* second, 34 arteriovenous fistulas and 29 arterial aneurysms operated upon in other army medical installations and studied subsequently at the Mayo General Hospital, and third, 5 arteriovenous fistulas and 3 arterial aneurysms which underwent "spontaneous cure" by thrombosis and required no operative treatment. Multiple lesions occurred in 9 patients who had a total of 22 fistulas and aneurysms. One arterial aneurysm resulted from acute medial necrosis, 2 intracranial carotid aneurysms were without known etiology, and 7 arteriovenous fistulas in 5 persons were congenital. One patient with signs of aortic valvular disease had a large mycotic aneurysm of the popliteal artery which almost certainly resulted from subacute bacterial endocarditis with embolism. The remainder were traumatic in origin.

SYMPTOMS, DIAGNOSIS, AND LOCALIZATION

Many of the patients had no symptoms referable to the aneurysm or fistula. Others were aware only of an abnormal pulsation, a pulsating mass, or a bruit or thrill. Those with intracranial aneurysm had headache and ophthalmoplegia, and those with fistula of the carotid artery and the cavernous sinus noted a buzzing noise in the head and a pulsating exophthalmos associated with ocular palsies. When subcutaneous rupture or rapid expansion of an aneurysm occurred there was often intense pain and sometimes loss of nerve function. In a few patients there was fatigue on exercising the limb in which the aneurysm or fistula was situated.

Those patients with cardiac dilatation resulting from an arteriovenous fistula sometimes had no related symptoms, but in a number of them there was dyspnea on exertion, palpitation, or an uncomfortable sense of pounding of the heart, particularly in the recumbent position. Evidence of definite myocardial insufficiency was present, however, in only two instances. One was in a patient who had a traumatic fistula of the external iliac artery and vein and also of the hypogastric vessels. Great dyspnea, orthopnea, and edema had developed shortly after the injury. These symptoms disappeared following resection of the iliac fistula in a hospital overseas. The second fistula was subsequently recognized and its excision brought about further reduction in size of the heart. In the other patient vegetations developed within a femoral arteriovenous fistula which gave rise to a *Streptococcus viridans* septicemia. He had pulmonary infarction and extreme orthopnea. Symptoms subsided rapidly after excision of the fistula.¹

In general, diagnosis presented no great difficulty. The signs present in arteriovenous fistula have long been recognized and are so precise and constantly present that they render diagnosis relatively easy. In the cases studied, a continuous bruit was invariably present, and a continuous thrill was absent in only a few instances where the fistula was very small. With a single exception there was a definite bradycardic reaction during compression of the fistula, and almost as regular was an elevation in blood pressure during

*This group includes one patient operated upon by one of us (H. B. S.) overseas in the 118 General Hospital and four operated upon at the Percy Jones General Hospital during the brief period when the Vascular Center was located there. For the sake of convenience these five patients will be included with those who were treated at the Mayo General Hospital.

this procedure. Often there was a rise in both diastolic and systolic pressure, the former occurring more uniformly and in greater degree than the latter. Generally the frontal cardiac area was demonstrably increased on roentgenographic examination in instances where there was a large fistula, with the exception of lesions of the carotid vessels in which cardiac enlargement was usually absent.

In cases of arterial aneurysm there was sometimes present a pulsating mass, a systolic bruit, and a systolic thrill. Not infrequently, however, a pulsating mass was not visible or palpable, particularly when the aneurysm was of small size and was covered by large muscles. Nevertheless, an abnormal pulsation was almost invariably present. With rare exception a pronounced systolic bruit was audible, but often the systolic thrill was absent. In two cases of intracranial aneurysm neither bruit nor thrill was present, but the correct diagnosis was suspected because of signs of ophthalmoplegia and was confirmed by arteriogram. Twice a mistake in diagnosis was made. One was in a patient with a very tense nontraumatic popliteal aneurysm without bruit or thrill which, before operation, was considered probably a cyst with transmitted pulsation rather than an arterial aneurysm. The other was in a patient who had an abnormal pulsation in one infraclavicular region associated with a loud systolic bruit and a foreign body visible by roentgenography in the clavicular area. Exploration was carried out in this patient under the impression that the condition was due to an aneurysm, but it was subsequently established that it was dependent upon costoclavicular compression of the subclavian artery.²

The correct localization of the aneurysm or fistula was generally easy, and in only a few cases was an error in localization made. The commonest difficulty arose in cases with lesions of the profunda femoral vessels in which the pulsation, bruit, and thrill could be eliminated only by compression of the overlying femoral as well as of the involved profunda vessels. In one instance a fistula between the internal mammary artery and the innominate vein was thought before operation to be a fistula of the innominate or subclavian vessels. In another patient who had a fistula between the transverse cervical artery and the internal jugular vein, exploration was done with a preoperative diagnosis of subclavian arteriovenous fistula. Still another patient with a fistula between the inferior geniculate artery and the popliteal vein was believed to have a popliteal arteriovenous fistula.

ARTERIOGRAMS

Arteriograms were made in a number of instances. The technique employed and the indications for this procedure and its value will be presented in another publication. It is our belief that such studies, although not without hazard, are reasonably safe. No reactions occurred, and good visualization of the lesion was obtained with relatively small amounts of 70 per cent diodrast. Arteriograms were found particularly helpful in cases of intracranial aneurysm without bruit or thrill where confirmation of the diagnosis was advisable before ligation of the carotid artery. They were very useful

in cases in which one could not be certain of the exact localization of the lesion, particularly when tests showed the collateral circulation to be poor and when the lesion might conceivably involve either some very important artery, such as the femoral, or a relatively unimportant one such as the profunda femoris. Arteriograms were likewise of considerable aid in cases in which it appeared that the aneurysm was being "cured" by thrombosis. It was found that arteriograms were unnecessary in the great majority of cases either for correct localization or for proper surgical treatment of the fistula or aneurysm.

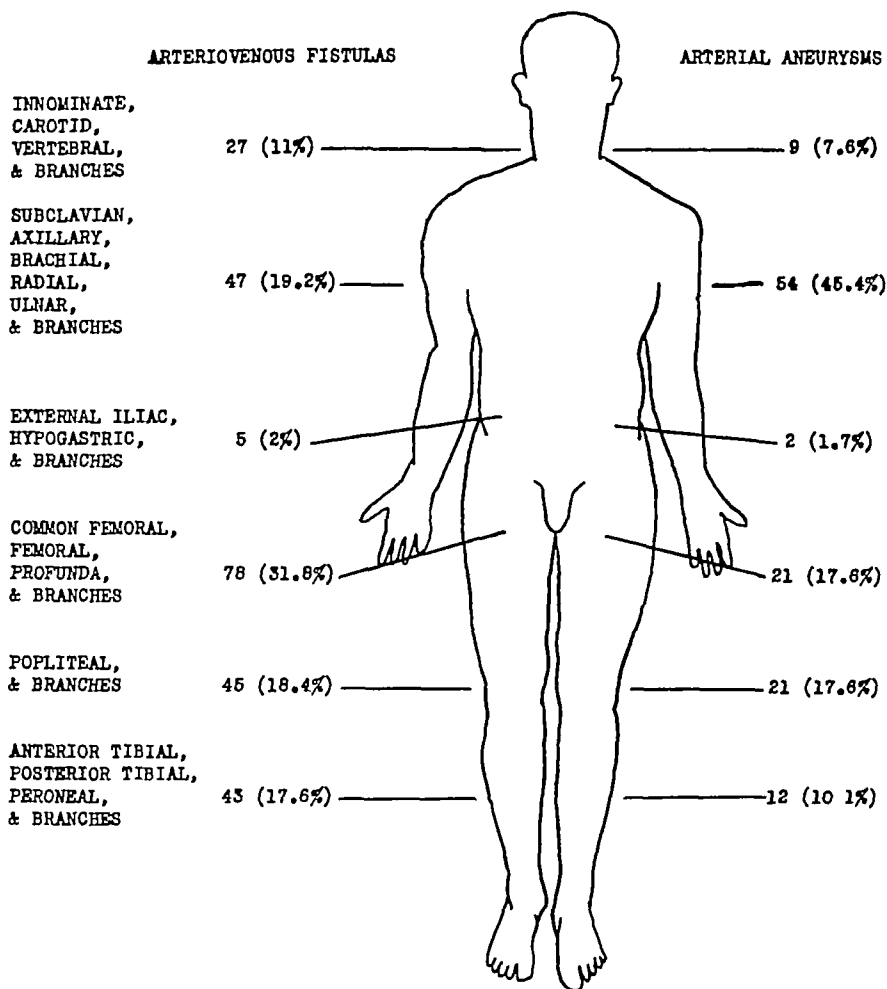


Fig 1.—Diagram showing general distribution of fistulas and aneurysms

DISTRIBUTION OF LESIONS

In Fig 1 the general distribution of the aneurysms and arteriovenous fistulas is shown, and in Table I the lesions are listed according to the affected artery. There were lesions of all the main peripheral arteries with the exception of the common iliac, and of most of their branches. There were no

aneurysms or fistulas of the abdominal aorta, but there were a few patients with involvement of the external iliac, hypogastric, superior gluteal, and obturator vessels. In five instances the aneurysm or fistula was within the anterior mediastinum. There were two intra-cranial aneurysms and two intra-cranial fistulas. The majority of the lesions were in the vessels of the limbs.

Important arteries, such as the aorta, the innominate, carotid, vertebral, subclavian, axillary, brachial, iliac, femoral, and popliteal, were affected in 162 of the 245 arteriovenous fistulas (66 per cent) and in 94 of the 119 arterial aneurysms (79 per cent). Less important arteries, such as the radial, ulnar, anterior or posterior tibial, peroneal, obturator, hypogastric, and branches of the main arteries, were involved in the remaining 34 per cent of the arteriovenous fistulas and in 21 per cent of the arterial aneurysms.

TABLE I DISTRIBUTION OF ANEURYSMS AND ARTERIOVENOUS FISTULAS

ARTERY INVOLVED	ARTERIOVENOUS FISTULAS, NUMBER OF CASES			ARTERIAL ANEURYSMS, NUMBER OF CASES		
	OPERATION AT M G H	OPERATION ELSEWHERE	"SPONTANE OUS CURE"	OPERATION AT M G H	OPERATION ELSEWHERE	"SPONTANE OUS CURE"
Aorta	1					
Innominate				1		
Internal carotid	3			2		
External carotid	3					
Common carotid	6		1	1	1	2
Vertebral	4					
Lingual	1					
Occipital	1					
Cirsoid, nose, ear	2					
Superior temporal	2			1		
Transverse cervical	1	1				
Deep cervical				1		
Internal mammary	1					
Subclavian	6	3	1	5		
Axillary	12			13	2	
Branch axillary	4			2		
Brachial	11	1	1	22	5	1
Radial	1	1		2		
Ulnar	4	2		2		
External iliac		1		1		
Hypogastric	1					
Superior gluteal	2			1		
Obturator	1					
Common femoral	3	2				1
Femoral	47	13	1	6	9	1
Profunda femoris	6			2		
Branch profunda	2	2	1	2		
Popliteal	41	1		14	6	1
Gemulate	4					
Posterior tibial	21	5		1	4	2
Anterior tibial	5	1		2	1	
Peroneal	5	1			1	
Branches in calf	5			1		
Total	206	34	5	82	29	8

It is of interest that the subclavian and popliteal vessels were involved in about the same percentage of cases in the group of arteriovenous fistulas and in the group of arterial aneurysms. On the other hand, the axillary and brachial vessels were much more commonly affected in the group of arterial aneurysms, whereas the femoral vessels were involved with greater frequency

in the group of arteriovenous fistulas (Table II) The incidence of arterial aneurysms of the femoral vessels was only one-half that of the arteriovenous fistulas, but was two and one-half times as great in the case of the axillary and four times as great in the case of the brachial vessels It is entirely likely that the common occurrence of arteriovenous fistulas in the femoral vessels may be linked with the relative fixation of the artery and vein to one another and to the surrounding tissues Conversely, the greater frequency of arterial aneurysms in the axillary and brachial arteries may be dependent upon the relative mobility and lack of fixation of the distal portion of the axillary and brachial vessels

TABLE II COMPARISON OF INCIDENCE OF ARTERIAL ANEURYSMS AND ARTERIOVENOUS FISTULAS IN THE MAIN PERIPHERAL ARTERIES

ARTERY INVOLVED	ARTERIOVENOUS FISTULAS		ARTERIAL ANEURYSM	
	NUMBER	PER CENT	NUMBER	PER CENT
Subclavian	10	4.1	5	4.2
Axillary	12	4.9	15	12.6
Brachial	13	5.3	28	23.5
Common femoral and femoral	66	26.9	17	14.3
Popliteal	42	17.1	21	17.6

In nine patients there were multiple aneurysms and fistulas One patient had a congenital lesion with three distinct fistulas involving the anterior and posterior tibial and the peroneal vessels The other aneurysms and fistulas were traumatic in origin One patient had four arteriovenous fistulas,³ one had two arteriovenous and one arterial aneurysm, two had one arterial aneurysm and one arteriovenous fistula, and the remaining four had two arteriovenous fistulas each These multiple lesions generally occurred as the result of multiple wounds by shell fragments or land mines In one soldier, however, the same fragment of metal produced a fistula both of the external iliac and of the nearby hypogastric vessels In another, arteriovenous fistulas of the vertebral and of the brachial vessels were caused by injuries received on two separate occasions

ASSOCIATED INJURIES AND COMPLICATIONS

A number of patients had sustained fractures in limbs in which an aneurysm or fistula occurred In one, the shattered fragments of the fibula lay within the aneurysmal sac In a few, amputation had been necessary of an extremity in which an aneurysm or fistula was present There had been extensive loss of muscles in a number of persons either from ischemia, infection, or direct trauma A few had superficial gangrene of digits or ulceration of skin Not infrequently patients with an aneurysm or fistula had soft tissue or bony injuries of other extremities, or thoracic or abdominal injuries Several had organic valvular heart disease One has been previously mentioned who had a mycotic aneurysm resulting from an infected embolus Still another patient has been referred to in whom vegetations which gave rise to *Str viridans* septicemia developed within an arteriovenous fistula

TABLE III PERIPHERAL NERVE LESIONS ASSOCIATED WITH FISTULAS AND ANEURYSMS

ARTERY INVOLVED	ARTERIOVENOUS FISTULAS						ARTERIAL ANEURYSMS					
	NERVE LESION REQUIRING OPERATION		NERVE LESION NOT REQUIRING OPERATION		NO NERVE LESION		NERVE LESION REQUIRING OPERATION		NERVE LESION NOT REQUIRING OPERATION		NO NERVE LESION	
	NUM BER	PER CENT	NUM BER	PER CENT	NUM BER	PER CENT	NUM BER	PER CENT	NUM BER	PER CENT	NUM BER	PER CENT
Brachial	8	61.5	1	7.7	4	30.8	24	85.7	1	3.6	3	10.7
Axillary	9	75.0	0		3	25.0	11	73.3	1	6.7	3	20.0
Subclavian	0		4	40.0	6	60.0	3	00.0	1	20.0	1	20.0
Popliteal	10	23.8	3	7.1	29	69.0	2	9.5	6	28.6	13	61.9
Femoral	5	8.2	16	26.2	40	65.6	1	6.2	3	18.8	12	75.0
Others	10	8.6	17	14.5	90	76.9	7	13.0	13	24.0	34	63.0
Total	42	17.1	41	16.7	162	66.1	48	40.3	25	21.0	46	38.7

By far the commonest complication was an associated peripheral nerve injury. In Table III data concerning these associated nerve palsies are summarized. Eighty-two of the 245 arteriovenous fistulas (33.8 per cent) were complicated by some nerve injury. In about one-half of these, the nerve injury was such as to require operative treatment, either neurolysis or neurorrhaphy. Seventy-three of the 119 patients with arterial aneurysm (61.3 per cent) similarly had associated nerve palsies. In approximately two-thirds of these seventy-three patients, neurolysis or neurorrhaphy was necessary. In the majority of these the associated nerve damage appeared to be the direct result of the initial trauma. In some, however, nerve dysfunction seemed to be partially or wholly the result of pressure by the aneurysm. The patients listed as requiring no surgical treatment had predominantly injuries to sensory nerves, such as the saphenous, which caused no distress or disability. Others had more serious nerve palsies but spontaneous recovery of function took place. A few had injuries of the vagus, the phrenic, or the cervical sympathetic nerves where it was felt that a successful repair could not be achieved or where the resultant paralysis was considered of little importance.

It will be noted in Table III that a very high percentage of the aneurysms or fistulas of the brachial and axillary vessels and, to only a slightly less extent, of the subclavian vessels were complicated by accompanying nerve palsies. Aneurysms and fistulas of the femoral, popliteal, and other vessels less commonly had associated nerve lesions. The high incidence of nerve injuries associated with vascular lesions of the large vessels of the upper extremity appears to be dependent upon the relatively great mass of the nerve trunks and their intimate relationship to the great vessels.

TESTS FOR ADEQUACY OF COLLATERAL CIRCULATION

Elsewhere⁴ we have discussed in detail our experience with the various tests for adequacy of collateral circulation in the limbs. We found that the most reliable and practical test which could be carried out before operation was the Matas reactive hyperemia test. Though it was of great aid and general reliability it was found not to be infallible. The chief difficulties arose from the occasional impossibility of compressing accurately the affected artery.

at the precise site of the fistula or aneurysm without concomitant occlusion of neighboring vessels. Our experience indicated that if, during the procedure, an excellent and complete flush occurred promptly, without further improvement upon release of the compressed artery, one could operate and ligate the involved artery if necessary with minimal risk of any ischemic difficulty. If, on the other hand, the test seemed indicative of poor or questionably adequate collateral circulation every effort was made to bring about improvement in the collateral circulation before operation. Another test which, though somewhat difficult to perform, was found to be a useful confirmatory preoperative test was the observation of the extremity for evidence of continued good circulation during prolonged compression of the affected segment of artery. The absence of pulses distal to an aneurysm or fistula in a limb which had maintained good circulation also proved indicative of adequate collateral circulation.

In our experience, the most useful sign which could be elicited at the time of operation was the maintenance of good color and warmth of the hand or foot during a prolonged period of accurate occlusion of the involved segment of the artery with a rubber-shod clamp. If an aneurysm or fistula is explored in a limb in which there is even the slightest evidence to suggest that the collateral circulation may be inadequate, it is imperative that the hand or foot be left undraped during the procedure, that the lesion be approached with great caution, and that extirpation be deferred in case this test is not satisfactory unless it is perfectly apparent that a cure can be brought about with maintenance of the continuity of the affected artery. The presence of good retrograde pulsation in the involved artery also proved a reliable indication of efficient collateral circulation.

With regard to lesions of vessels supplying the brain we have felt it advisable to defer operation until the patient could withstand compression of the involved artery for thirty minutes without subjective or objective symptoms. In addition, we have used electroencephalographic studies performed at rest and during compression of the affected artery in an effort to obtain further data concerning the efficiency of collateral circulation. These studies will be reported subsequently. It may be said that they seemed to shed little or no light upon the problem that could not be obtained by careful observation of the patient during occlusion of the artery.

It must be pointed out that all methods of testing the collateral circulation to the brain or limb are based upon the assumption that no collateral vessel will be unnecessarily sacrificed during the operation, and that no post-operative thrombosis will occur.

METHODS OF INCREASING THE EFFICIENCY OF THE COLLATERAL CIRCULATION

There can be no doubt that one of the most important factors in the development of adequate collateral circulation in cases of arteriovenous fistula is the duration of the lesion. There is less convincing evidence that the same may be true in cases of arterial aneurysm. In general, it may be said that the older the arteriovenous fistula, the better the collateral circulation, and vice

versa It must be pointed out, however, that numerous exceptions to this observation were found The collateral circulation was sometimes excellent in cases of only brief duration and inadequate in others of long duration For example, the inadequacy of the collateral circulation in a limb in which there was a femoral arteriovenous fistula of eleven months' duration was established not only by numerous preoperative tests but by demonstration of extreme pallor and coldness of the foot during temporary occlusion of the isolated artery at the time of operation Fortunately, in this case, the fistula could be cured with preservation of the continuity of the artery

As a general rule there is nothing which makes early operation imperative, and in most of the patients included in this study operation was not performed until the lesion was of four months' duration or longer The economic factor incident to delay in operation and prolonged hospitalization cannot be considered a contraindication to delay, since one cannot subject a patient to added danger of some ischemic disaster upon such grounds There are, however, exceptions which render delay in operation either hazardous or inadvisable External rupture of an aneurysm or fistula makes operation imperative, for even momentary delay may endanger the patient's life Subcutaneous rupture may force early operation because of the associated intense pain, the onset of pressure paralysis, or ischemic difficulties Similarly, infection in or about an aneurysm or fistula may make it necessary to operate at once Severe myocardial insufficiency due to a fistula may make early operation necessary This condition influenced the selection of the time of operation in two patients The rare complication of infected vegetations within a fistula and septicemia similarly may make delay impossible By far the commonest factor in rendering prolonged deferring of operation unwise is the presence of associated severe nerve paralysis There can be no doubt that the earlier such peripheral nerve injuries are treated, the better is the chance for good recovery of function

Among the several methods available for increasing the collateral circulation are partial proximal ligation of the artery, repeated intermittent digital or mechanical occlusion of the artery, and sympathetic interruption Partial proximal ligation is applicable only in cases of arterial aneurysm and not in arteriovenous fistulas This method was used only once in the present series of cases, in the treatment of an innominate aneurysm In this particular instance definite beneficial results of the procedure were not evident, although its general worth is well established

Repeated occlusion of the artery is a very useful procedure Often during the course of such treatment improvement in the efficiency of collateral circulation is so slow, however, that one cannot be certain that the method is actually accomplishing definite results On the other hand, in other instances one can be quite certain that the compression is hastening the development of adequate collateral circulation, either by rapid progress in the patient's ability to withstand, without the appearance of symptoms, the occlusion of an artery supplying the brain, or by the steady rapid improvement in the collateral circulation of a limb as judged by the reactive hyperemia and other tests

The third method sympathectomy, we have utilized extensively. The results of sympathectomy performed in an effort to render the collateral circulation more efficient will be presented in detail in another publication, hence these experiences will be discussed only briefly here. Seventy-seven sympathectomies were carried out before or at the time of operation. Thirty-six lumbar and twelve dorsal sympathectomies were done in patients with arteriovenous fistula, and seventeen lumbar and twelve dorsal sympathectomies in those with arterial aneurysm. The great majority of the lumbar sympathectomies were done for femoral and popliteal lesions, whereas most of the dorsal operations were carried out for lesions of the axillary vessels. The principal indications for this procedure were as follows: evidence of poor collateral circulation in lesions of adequate duration, definitely impaired circulation in limbs in which paralysis of nerves was present, persistent intense vasospasm, the presence of ischemic lesions in the affected extremity, lesions of important arteries which could not be compressed, making it impossible to test the collateral circulation, and associated causalgia.

The results of the procedure were generally good. Almost invariably tests for efficiency of collateral circulation showed improvement following operation. In many patients the formerly poor collateral circulation appeared to be perfectly adequate either immediately after sympathectomy or during the first few weeks after this operation was performed. In some instances, however, the collateral circulation, although improved, did not appear to be satisfactory. Eventually all of these patients were cured by operative treatment except two who underwent a "spontaneous cure." In those cases where there was evidence of obviously impaired circulation or of intense vasospasm before the performance of sympathectomy, definite improvement in the circulatory status of the limb was noted following this procedure. In general, it was believed that this study confirmed the usefulness of sympathetic interruption in rendering the collateral circulation more efficient. It demonstrated, however, that the procedure has limitations and is by no means infallible. Indeed, the only limb in which gangrene developed immediately after excision of a fistula or aneurysm had been sympathectomized, and similarly the only instance in which ischemic paralysis followed operative cure of an aneurysm at the Mayo General Hospital, was one in which sympathectomy was performed at the conclusion of the operation.

TREATMENT

It is not our purpose to present here in detail the operative approach to lesions of the various vessels or precise descriptions of operative techniques which we have found useful. Certain of these problems have been presented elsewhere^{5, 6} or will be discussed later in other reports. We desire, however, to mention briefly some broad principles of surgical management which have proved to be important.

The following objectives should be sought in the operative treatment of aneurysms and fistulas: preservation of life, cure of the lesion, preservation of neighboring structures without injury, maintenance of adequate circula-

tion, and avoidance of disabling scars and contractures. It is therefore important that operative exposure be ample, that one have ready access if possible to the involved and adjacent vessels both proximal and distal to the lesion and to their branches, that hemostasis and asepsis be carefully maintained, and that supportive measures such as the administration of plasma and blood be utilized when advisable. As has been mentioned previously, one should be reasonably certain from preoperative tests of the adequacy of the collateral circulation, and if this fact cannot be established beyond reasonable doubt before operation it should be demonstrated by other tests and observations at the time of operation before any direct attack upon the lesion itself which might entail ligation of the affected artery.

In approaching aneurysms and fistulas it is of the utmost importance that the skin incision be so placed that it permits easy and complete exposure of the involved vessels, and that it be such that it can be lengthened if necessary to make accessible the vessels distal and proximal to the site of the suspected lesion. Furthermore, it is desirable that the incision be one which will yield a good plastic result and will render minimal the hazard of scarring, contracture, and keloid formation, complications which result far too frequently from incisions which follow the course of the vessels longitudinally across the axilla, the antecubital space, and the popliteal fossa, and which cross the normal skin creases of the neck and groin. In this series of cases it was found feasible to utilize skin incisions which were sound from a plastic viewpoint without sacrificing facility or rapidity of adequate exposure of the vessels.⁵

It is our belief, in general, that operations should be done without the use of a tourniquet. We have reserved the tourniquet for large arterial aneurysms or arteriovenous fistulas associated with large saccular aneurysms in which the isolation of the proximal and distal vessels would otherwise have been difficult and would have entailed much needless and perhaps damaging dissection. There are several advantages of operating without a tourniquet. Chief among these is the fact that the localization of the lesion is facilitated by the presence of the pulsation, bruit, and thrill, especially in the case of arteriovenous fistulas, and the fact that observation of the color and warmth of the limb during precise temporary occlusion of the involved artery is such a valuable aid in confirming the efficiency of the collateral circulation.

Arterial aneurysms were treated at the Mayo General Hospital by four methods, excision, intrasaccular ligation of the artery, intrasaccular ligation of the artery followed by excision of the sac, and, in a few instances, proximal ligation of the affected artery. Excision following isolation and control of the proximal and distal artery was utilized chiefly in those instances where the sac was small and where neighboring nerves and vessels could readily be dissected free and preserved from injury. Intrasaccular approach to the artery was employed primarily for large aneurysms not associated with peripheral nerve lesions. In certain instances the artery was dissected out and temporarily occluded above and below the sac, in others the operation was done under a tourniquet. The sac was incised and the openings of the artery were identified. Instead of the usual intrasaccular transfixion of the artery

proximal and distal to the openings, it was our policy to excise a small portion of the sac wall immediately overlying these vessels, to dissect them out individually, and to occlude them with transfixing ligatures. This precaution was taken because we felt it made more certain accurate ligation of the vessels without hazard of injury to neighboring structures such as nerves. We made no effort to obliterate the sac itself by suture, indeed, this was generally impossible because of the huge size of the sac and often because of the poorly developed character of its wall. If any portion of the sac wall could be readily excised, this was done.

Intrasaccular ligation of the vessels followed by complete or subtotal excision of the sac was utilized chiefly in those instances where the aneurysm was closely adherent to nerves which could not readily be freed from it beforehand. The majority of these cases involved the subclavian, axillary, or proximal brachial artery. First the artery was isolated proximally and distally and was temporarily occluded with rubber-shod clamps. The sac was then opened and any laminated thrombus was evacuated. All of the adjacent nerves and trunks were isolated and identified. Ordinarily such operations were done as a combined procedure with members of the neurosurgical section. Only after all the nerves had been freed and identified was the sac excised. Our experience emphasized the importance of such precautions. In a number of cases nerves as large as the trunks of the brachial plexus were so intimately incorporated in the sac wall and so distorted in configuration and color that they appeared not as nervous tissue but as a portion of the sac wall itself. Excision of the sac was generally necessary in order to effect proper surgical correction of associated nerve injuries. Proximal ligation of the affected artery was reserved for the few instances of intracranial carotid aneurysms. Where it was deemed feasible the continuity of the artery was preserved by end-to-end suture, vein graft, or lateral suture, regardless of the method of ablation of the aneurysm itself. In the majority of cases, and in all in which there was any question as to the excellence of the collateral circulation, the concomitant vein was divided and ligated.

The operative technique which was almost invariably used in the cure of arteriovenous fistulas was excision with quadruple ligation of the affected artery and vein together with ligation of branches which communicated with the fistula. In four instances, however, proximal ligation of the artery and vein was carried out—in two cases of fistula of the carotid artery and cavernous sinus, in one case of a high internal carotid-jugular fistula, and in one case of a profunda femoral fistula in which the actual site of the fistula could not be established at the time of operation. In every operation upon an arteriovenous fistula or arterial aneurysm great care was taken to preserve every collateral vessel which was not directly involved in the lesion itself. Each fistula was approached and carefully dissected out with the view of establishing first the feasibility or impracticability of some type of procedure which would make possible the preservation of continuity of the involved artery. When it was possible, the artery was kept intact or was restored by ligation.

and transfixion of the fistula, lateral arteriorrhaphy, end-to-end suture, or vein graft

When it was advisable the fistula was dissected out and was occluded by transfixing ligatures at the point where it joined the wall of the artery. This procedure was employed in eleven patients. In all save one the vein was divided above and below the fistula, and a cuff of vein plicated by transfixing sutures was used to reinforce the ligated fistulous tract. In six cases of aneurysm or fistula, lateral suture was accomplished. Interrupted everting mattress sutures were used and the opening in the artery was closed along the long axis of the rent. In cases of arteriovenous fistula the opening was exposed by section of the attached vein. In ten cases end-to-end suture of the artery was carried out by use of interrupted everting mattress sutures. This type of repair was particularly applicable in lesions of the brachial or distal axillary vessels where the artery could be readily mobilized and length could be gained by suitable posturing of the extremity. In six cases vein grafts were used. These were sutured in place similarly with interrupted everting mattress sutures. In most instances other than those of ligation of a fistula, anticoagulants were used.

Altogether such reparative procedures were accomplished in only thirty-three instances. Several factors made it difficult to restore the continuity of blood flow through the affected artery, particularly since the great majority in our series were traumatic lesions consequent to shell fragments, land mines, or bullets. In these cases the extent of damage to the arterial wall was very extensive in contrast to the limited injury which is the rule when such lesions result from stab wounds, for example. There was frequently gross and much more often microscopic evidence of injury to the arterial wall not only at the site of the aneurysm or fistula but for some distance proximally and distally. Furthermore, most of the arteriovenous fistulas were not simple fistulas but were complicated by one or more false saccular aneurysms as well. Consequently, it was often necessary to excise a portion of the artery, thus eliminating as a possible means of repair the simpler methods such as ligation of fistula or lateral suture. In such cases, end-to-end suture or vein graft was frequently impossible because of the presence of some important collateral artery which emerged so close to the severed end of the artery that it would of necessity have to be sacrificed if repair were attempted. It was our belief that it was unwise to destroy any collateral vessels.

A review of our cases demonstrates that reparative procedures were possible in a larger number of patients than were actually so treated. It is ordinarily unnecessary to attempt any type of restoration of blood flow of the smaller arteries, such as the radial, ulnar, anterior and posterior tibial, peroneal, and the small branches of the larger arteries. If we include only the larger arteries which form the main channels of blood flow into a part we find that the continuity of the vessel was restored in only 4 of the first 150 such cases (2.7 per cent), whereas this was accomplished in 29 of the last 55 such cases (52.7 per cent). This difference is due, we believe, to the fact that in the first group of patients exploration was carried out with the idea of

attempting arterial repair provided it appeared that normal arterial structures could be utilized and the procedure could be performed without undue difficulty, while in the second group patients were operated upon with the determination to carry out a repair in every instance in which this could possibly be accomplished short of leaving in situ obviously badly damaged portions of arterial wall and of sacrificing collateral arteries

Those patients described in this review who were operated upon in other hospitals were generally treated by excision or aneurysmorrhaphy in the case of arterial aneurysms, and by excision with quadruple ligation in the case of arteriovenous fistulas

RESULTS OF TREATMENT

In general, the results of operative treatment were good. Cure of the aneurysm or fistula was achieved in all instances save one. This was a patient with clinical and x-ray evidence of an arteriovenous and a saccular aneurysm in the anterior superior mediastinum. Upon exploration a large aneurysm was found which appeared to involve not only the right innominate and the left subclavian vessels but the arch of the aorta and the superior vena cava as well. The chance of surgical cure appeared technically impossible. Several patients who had undergone surgical exploration and attempt at treatment in other hospitals were subsequently cured at the Mayo General Hospital. Among the 288 aneurysms and fistulas operated upon at the Mayo General Hospital multiple operations were necessary in six instances. Two of these were cases of vertebral arteriovenous fistula, in one of which the lesion could not be identified at the first operation, and in the second of which a proximal ligation which failed to effect a cure was first attempted. One was an innominate arterial aneurysm in which partial proximal ligation was done at the initial operation because of inadequate collateral circulation. Another was a small aneurysm in the calf which escaped localization during the first exploration. Still another was a femoral arteriovenous fistula in which operative attack was deferred initially because of poor collateral circulation. The last was an arteriovenous fistula of the brachial vessels in which a simple double ligation of the fistula was followed by recurrence of signs of arteriovenous communication. In all instances a cure was effected at the second operation.

The great majority of the patients showed no evidence of circulatory insufficiency after operation as observed at rest and with moderate exercise about the wards. The limbs were well colored, warm, and without diminution in motor power or sensation. On such casual examination the circulation appeared entirely adequate. The activity and the environmental conditions in the hospital are, however, often far different from those which patients will encounter after return to duty or to civilian life. It is consequently necessary to inquire into the ability of such limbs to withstand more strenuous exercise and extremes of environmental change. Upon such testing it was found that a number of patients had complaints which had hitherto been undetected. A certain number of those whose treatment had necessitated ligation of the affected artery had a definite sensitivity to cold. In some, this was so moderate

as to require no further treatment. In others, an annoying sensitivity to cold offered no real problem since the individuals lived in warm climates where they would rarely be subjected to cold temperatures. In those, however, who had such cold sensitivity and lived in cold sections of the country the problem was real and necessitated attempts at correction of the difficulty. When small arteries, such as the radial, ulnar, anterior or posterior tibial, peroneal, and other small branches, had been ligated there was rarely any significant diminution in tolerance of exercise. Furthermore, when the subclavian, axillary, or brachial artery had been ligated there was frequently no subjective complaint on moderate exercise, although ergometric studies and more strenuous exercise generally demonstrated some weakness and fatigability. When the main arteries to the lower extremity had been divided there was, as a general rule, a noticeable fatigability on exercise. Such patients could walk for a given distance but would then have to stop and rest for a moment because of a sense of fatigue or tightness in the calf, following which they could again walk for the same distance before return of the same symptoms. In contrast, most of those patients in whom the continuity of the artery had been maintained noted no significant decrease in the ability to exercise the limb.

Sympathectomy was performed at the Mayo General Hospital in thirty-four instances in order to alleviate certain difficulties which followed operative cure of an aneurysm or fistula. The patients so treated included some who had been treated in hospitals overseas and others who had been treated at the Mayo General Hospital. The chief indications for this procedure were cold sensitivity, obviously impaired circulation in the presence of associated nerve paralysis, and, in a few instances, persistent edema or evidence of continued sympathetic overactivity. As has been mentioned previously, the value of sympathectomy in the treatment of aneurysms and fistulas will be presented fully in another paper. It may be stated here that the results were in general good, although complete alleviation of symptoms did not follow in every instance.

The results of operative repair of arteries were generally excellent. It must be pointed out, however, that of the thirty-three cases in which some type of reparative procedure was accomplished, the success of some appeared very questionable at the time of operation because of extensive damage to the wall of the artery. Repair was attempted in some cases of this sort in order to shed some light upon the limitations as well as the applicability of the procedures. There were six failures among the thirty-three repairs. One of these was the ill-advised simple ligation of a fistula, already mentioned, one was a suture carried out in the presence of gross infection, one was a vein graft in the repair of a brachial artery of unusually small caliber, and three were instances in which the damage to the arterial wall was so extensive that the outcome was obviously questionable. In all instances in which relatively good arterial structures were sutured in the absence of gross infection and in which the caliber of the artery was 3 mm or greater, the outcome of the procedure was excellent.

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ordinarily be delayed indefinitely in order to permit development of more adequate collateral circulation, certain complications often made earlier operation advisable. Among the various methods of attempting to increase the adequacy of the collateral circulation, sympathectomy was found to be a very useful although not completely reliable aid. The commonly employed techniques of dealing with aneurysms and fistulas were utilized. The special applicability of these methods has been discussed. The problem of restoration of continuity of the affected artery has been presented. The results of treatment were in general good, although two deaths and a number of complications occurred.

Chief among those problems which appear to deserve further intensive study are means of testing more accurately the adequacy of the collateral circulation, methods of increasing the efficacy of the collateral circulation, and the general problem of maintaining the continuity of the involved artery.

The authors wish to express grateful acknowledgment to all those medical officers who had a part in the care of the patients included in this study.

REFERENCES

- 1 Shumacker, H. B. Jr, Welford, N. T., and Carter, K. L. Streptococcus Viridans Septicemia From Vegetations in Femoral Arteriovenous Aneurysm, Report of a Case Cured by Surgical Excision of the Aneurysm, Ann. Surg. (In press)
- 2 Shumacker, H. B., Jr. A Case of Costoclavicular Compression of the Subclavian Artery Simulating Arterial Aneurysm, SURGERY (In press)
- 3 Shumacker, H. B., Jr. Multiple Arteriovenous Aneurysms, SURGERY 18: 646-650, 1945
- 4 Shumacker, H. B., Jr, and Carter, K. L. Tests for Collateral Circulation in the Extremities, Arch. Surg. (In press)
- 5 Shumacker, H. B., Jr. Incisions in Surgery of Aneurysms, With Special Reference to Exploration in the Antecubital and Popliteal Fossae, Ann. Surg. (In press)
- 6 Shumacker, H. B., Jr. Arteriovenous Fistulas of the Cervical Portion of the Vertebral Vessels, Surg., Gynec. & Obst. (In press)

CERTAIN ASPECTS OF BATTLE WOUNDS OF THE THORACIC CAVITY

WITH SPECIAL REFERENCE TO A METHOD OF FACILITATING RE-EXPANSION OF THE
LUNG FOLLOWING LATE DECORTICATION

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AT THE beginning of World War II most thoracic surgeons anticipated that the care of battle wounds of the thoracic cavity would be far superior to that provided in any previous war. I for one anticipated that partial pulmonary resection or the repair of lacerations in pulmonary tissue would be a commonplace procedure. However, experience has shown that the lung has a remarkable ability to recover from penetrating or lacerating wounds so that resection of pulmonary tissue or the suture of lacerations in the lung was seldom found to be necessary. The real therapeutic advances were made in another direction.

During the course of the war it became increasingly apparent that the fundamental objective in the treatment of battle wounds of the thoracic cavity should be complete re-expansion of the lung as early as possible.

Hemopneumothorax—Before the war there were many who believed that the patient with a simple hemothorax or hemopneumothorax should be treated conservatively and that thoracentesis should be resorted to only in the event of considerable dyspnea. There were others who believed that if the blood were removed by thoracentesis, it should be replaced by air in order to prevent too rapid re-expansion of the lung.

I believe it can be said that as the result of the experience gained in this war, the opinion is now almost universal that better results are obtained by early thoracentesis so as to bring about more rapid re-expansion of the lung. In the campaign of North Burma we were in the favorable position of receiving the wounded early and keeping them until they were well. Early in the campaign I deliberately set out to treat some patients with massive hemothoraces by early thoracentesis and some with no thoracentesis. The conservative treatment was soon abandoned. While it is true that even large hemothoraces were often absorbed, it was observed that the patients took longer to recover and that they were often left with marked residual changes. There was x-ray evidence of considerable thickening of the pleura and physical examination very often disclosed marked fixation of the involved hemithorax.

The primary objection to early thoracentesis in the treatment of hemothorax has been the fear that early re-expansion of the lung might cause a recurrence of the bleeding. This has certainly not proved to be the case. In a series of more than 350 wounds of the thoracic cavity I was never aware that re-expansion of the lung precipitated fresh bleeding. Re-expansion of the lung was usually not attempted until forty-eight to seventy-two hours after injury unless the patient was dyspneic. Seldom was more than 750 to 1,000 cc of blood removed

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at one thoracentesis. The procedure was repeated every day or two until the lung was re-expanded as completely as possible.

The advantages of obtaining early re-expansion of the lung are (1) to avoid the residual changes in the pleura, (2) to speed up the convalescence, and (3) to decrease the size of an empyema should infection occur. The objection to removing the blood from the pleura and replacing it with air is, of course, that it leaves the lung collapsed and increases the size of the empyema should infection occur.

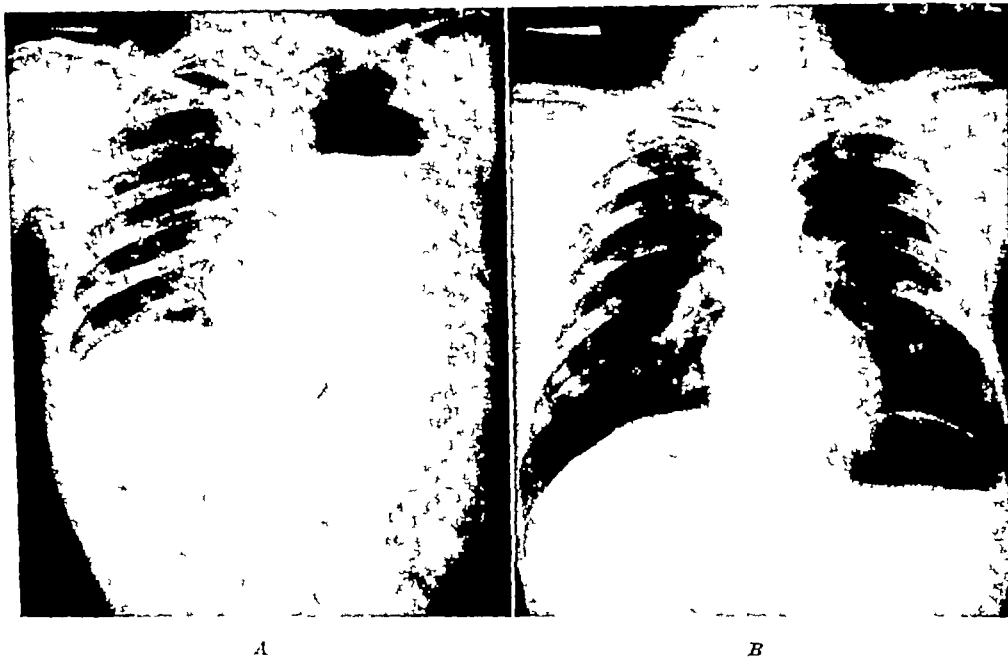


Fig. 1.—A, A 25 caliber bullet perforated the left side of the chest of an American officer forty-eight hours before this roentgenogram was taken. He was not severely dyspneic. B, A total of 2,000 c.c. of bloody fluid was removed by three thoracenteses. This view was taken one week later or nine days after he was wounded. Physical examination showed the lungs to be clear. He made a rapid recovery.

Pneumothorax—Occasionally a patient was seen who had a pneumothorax with little or no blood in the pleural cavity. Here too it was learned that early re-expansion of the lung was desirable. If the pneumothorax was gradually increasing in size, it would often be controlled by repeated thoracenteses. The opening in the lung usually closed after a few days and thoracentesis resulted in complete re-expansion of the lung. A pneumothorax apparatus was often found to be helpful in these cases.

In the presence of a real tension pneumothorax which reaccumulates rapidly after thoracentesis, there should be no hesitancy in introducing a catheter into the pleural cavity to allow the continual escape of air. In no patient in this series was it necessary to suture a tear in the lung because of persistent pneumothorax. In one patient, however, while the inter-rib catheter relieved the tension pneumothorax, the associated subcutaneous emphysema continued. It became apparent that the air was escaping into the mediastinum from the

tracheal wound incident to the great increase in the intratracheal pressure which occurred during coughing. Simple tracheotomy prevented the building up of a high intratracheal pressure during coughing and the emphysema disappeared progressively thereafter.

Clotted Hemothorax—Decortication of the lung in the presence of a clotted hemothorax was first used extensively in the Mediterranean Theater under the supervision of Churchill.¹ Speaking as one who treated several of these patients conservatively early in the war, I am certain that they are left with a fibrothorax which considerably reduces the functional capacity of the thorax.

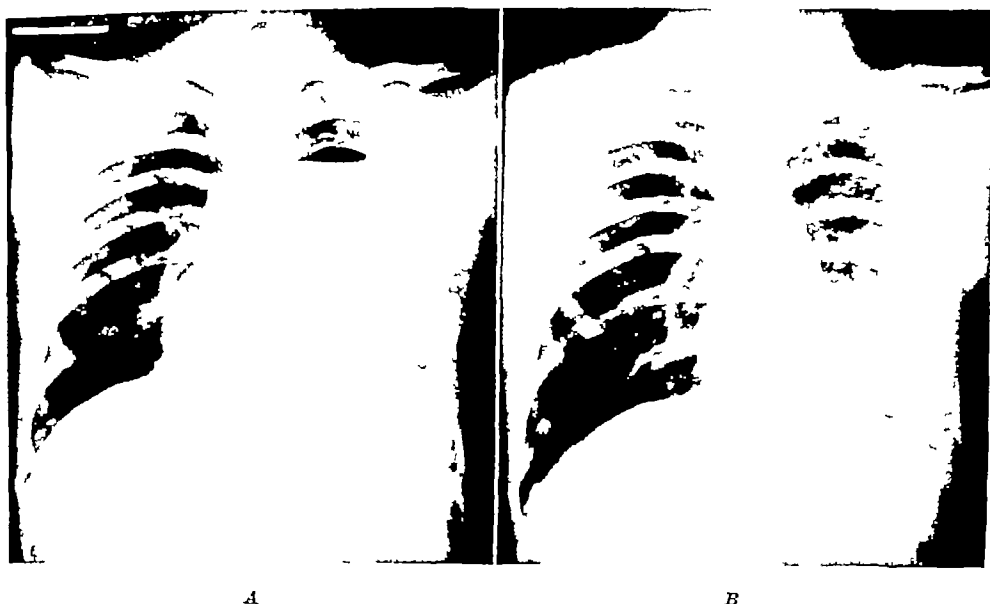


Fig 2—A, Roentgenogram taken one week after the left side of the chest of a Chinese soldier was perforated by a .25 caliber bullet. He was not severely dyspneic. He was treated conservatively without thoracentesis. B, The fluid in the chest disappeared very slowly. This view was taken six weeks later. It shows only moderate thickening of the pleura. However, physical examination revealed marked limitation of motion on that side with markedly decreased breath sounds. His convalescence was prolonged.

Early decortication of the lung as practiced in these patients is now accepted by all who had the opportunity of caring for thoracic injuries. When operation is performed in the first few weeks, the liquid blood and exudate may first be removed leaving behind a fibrinous layer of tissue covering the surface of the partially collapsed lung. This layer of tissue may then be peeled from the lung surface, thereby permitting immediate complete re-expansion of the lung.

Infected Hemothorax—Acute Empyema—Early in the war, I treated empyemas in the conventional manner. I did repeated thoracenteses to re-expand the lung as much as possible until the pus was thick enough to assure fixation of the lung and mediastinum in the presence of an open thoracostomy. I was not satisfied with the rather slow re-expansion of the lung obtained by open drainage. Early closed drainage was then used in some patients because it offered the advantage of possible application of suction and, thus, assistance in

the more rapid re-expansion of the lung. On the other hand, the amount and viscosity of the exudate in many patients obstructed the inter-rib catheter and made the suction ineffectual.

A method was then devised which provided the advantages of both open and closed drainage. A large opening was made in the chest wall by taking out sections of two ribs, and all the exudate was cleaned out. In order to re-expand the lung more rapidly the open drainage was then reconverted into a closed



Fig 3—A Chinese soldier had a tension pneumothorax on the right side with marked mediastinal and subcutaneous emphysema. The subcutaneous emphysema extended from above the ears to the backs of the fingers and halfway down the thighs. The tension pneumothorax was relieved by an inter-rib catheter. The subcutaneous emphysema continued to increase upon coughing. The course of the bullet indicated that the mediastinal trachea had probably been perforated. A tracheotomy was done to prevent the tremendous increase in intratracheal pressure upon coughing. The subcutaneous emphysema decreased progressively thereafter.

system, using the airtight seal demonstrated in Fig 5. The idea of using wide exposure first was to remove the exudate completely. A $\frac{3}{4}$ inch rubber tube was used for drainage which was not easily plugged by exudate. Using a high degree of negative pressure (100 to 150 cm. of water) it was found that the lungs re-expanded much more rapidly than would have occurred by simple open drainage or by closed drainage as commonly used.

Having become confident of being able to convert an open thoracostomy into a closed one, I then began to operate upon infected hemothoraces as soon

as the diagnosis was made. Intriatracheal anesthesia was used and a large opening was made as described. The blood and exudate were removed, although decortication of the lung was not done. The latter, while already adopted in the Mediterranean Theater of Operations, had not come to my attention. At this early stage, however, the layer of fibinous exudate over the lung was quite thin so that when a high degree of negative pressure was applied the lung re-expanded rapidly. When the pleural space had been reduced to the size of the large tube, a smaller tube was inserted and suction continued. Suction was continued until the cavity measured less than 5 cc. During the Central Burma Campaign decortication of the lung was added to this procedure. A large ($\frac{3}{4}$ inch) rubber tube and a high degree of suction continued in use, care being taken that the pleural space was completely obliterated before removing it.

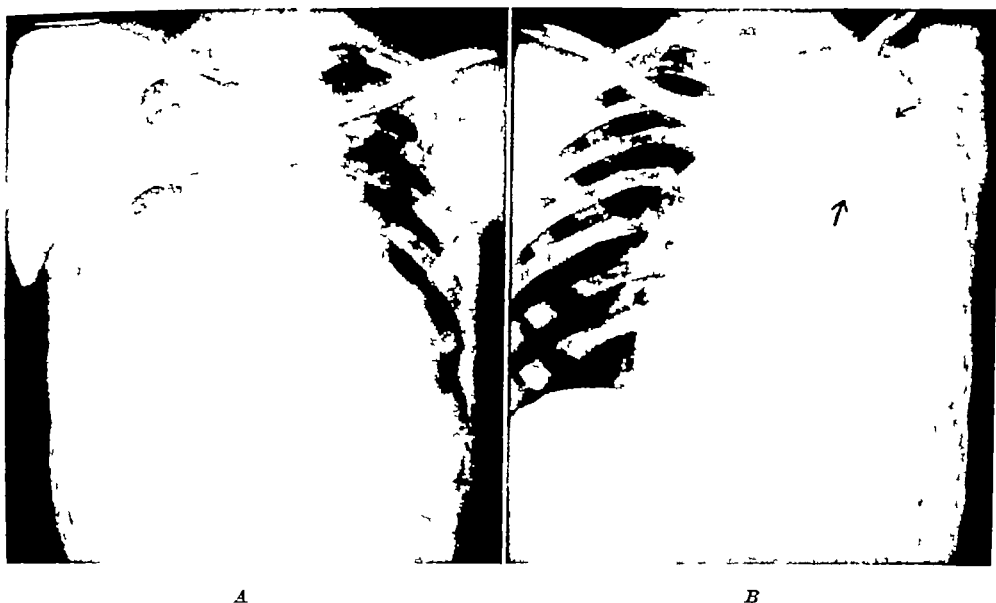
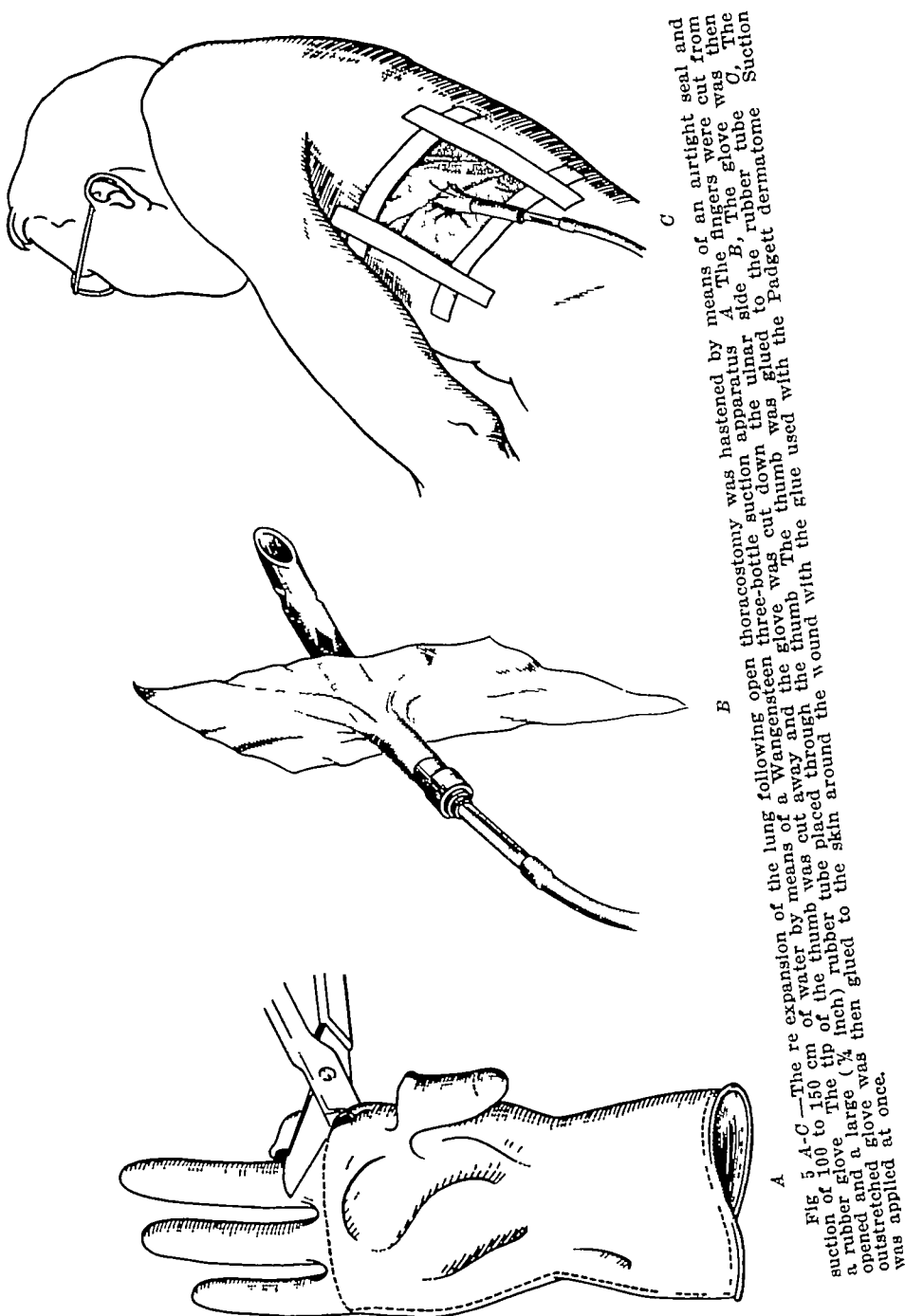


Fig 4 A and B—Two examples of clotted hemothorax. A has multiple fluid levels while B has only two small fluid levels which are not easily seen. Only a small amount of fluid could be obtained by thoracentesis in either case. These represent the type of clotted hemothorax which responds well to decortication as has been demonstrated in every theater of the war. When left alone a partially disabling fibrothorax develops.

Burford, Parker and Samson² have reported twenty-five patients with infected hemothorax upon whom decortication was performed. They obtained good results. It was then practice to use a drainage tube for only a few days, so that six patients developed secondary basal empyema and required secondary operation. Perhaps this could have been avoided by using a large tube with suction as was done in our case. Decortication in these early cases of empyema has now been fairly widely used.^{5, 6}

Infected Open Sucking Wounds—Occasionally a patient was seen in the rear echelon whose sucking chest wound had been sutured in the forward area but had broken open to become sucking again. Because of the loss of tissue and the presence of infection it may have been impossible or inadvisable to close the chest wall. Here the problem is one of obtaining re-expansion of the lung.



rather than of closing the chest wall wound. In three such patients the open wound was converted into a closed thoracostomy by means of the airtight seal previously described. In two of these patients the lungs re-expanded rapidly, became adherent, and the final results were excellent. In the third patient a bronchopleural fistula temporarily delayed re-expansion, but later complete re-expansion was obtained.

Chronic Empyema—Decortication of the lung for chronic empyema has been used occasionally for many years.^{3, 4} Before the advent of chemotherapy, however, most surgeons feared the dangers of spreading infection. Up until this war, as a rule, the patient with chronic empyema whose lung would not re-expand completely was subjected to a destructive operation in order to obliterate the remaining cavity.

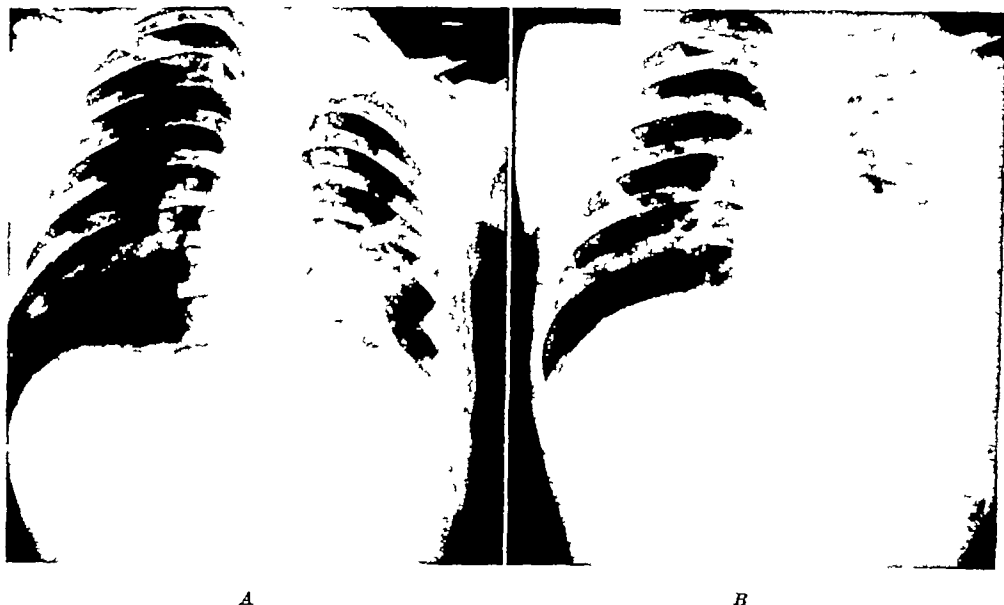


Fig 6—A. A Chinese soldier two months after being wounded with an open empyema and almost total collapse of the lung. B. Suction of 150 cm of water was applied by the method shown in Fig 5. Within a period of one month complete re-expansion of the lung had been obtained.

Decortication of the lung as popularized in this war was suggested primarily for early cases. The procedure has been used widely and in most instances has given excellent results. Kay and Meade⁶ have noted that the results were much better when the pleura was drained. As we gained confidence in being able to carry out the mechanical aspects of decortication, and with the aid of chemotherapy to help prevent spreading infection, it was inevitable that late decortication should be attempted.

During the Central Burma campaign a British soldier came under my care with a four-month-old empyema and total collapse of the left lung. Since the alternative was a total thoracoplasty, decortication was carried out. The result was very satisfactory (Fig 8). A layer of fibrous tissue covering the lung was tightly adherent to the surface of the lung and in places had to be separated from it by sharp dissection. Inevitably several openings were made in the lung. The

larger tears were sutured but there were still multiple small leaks. A large rubber tube ($\frac{3}{4}$ inch) was used for drainage under water. Suction was applied once each day to determine whether the multiple small bronchiopleural fistulas had closed. A Wangenstein suction apparatus was used. For the first three days the bronchiopleural fistulas remained open. On the fourth day there was no longer any leak and the lung rapidly became completely re-expanded.

Upon return to the United States I found that Lt. Col. Brian Blades and his associates at the Walter Reed General Hospital had been doing decortication in late empyemas and had been successful as late as eight months following the original injury.

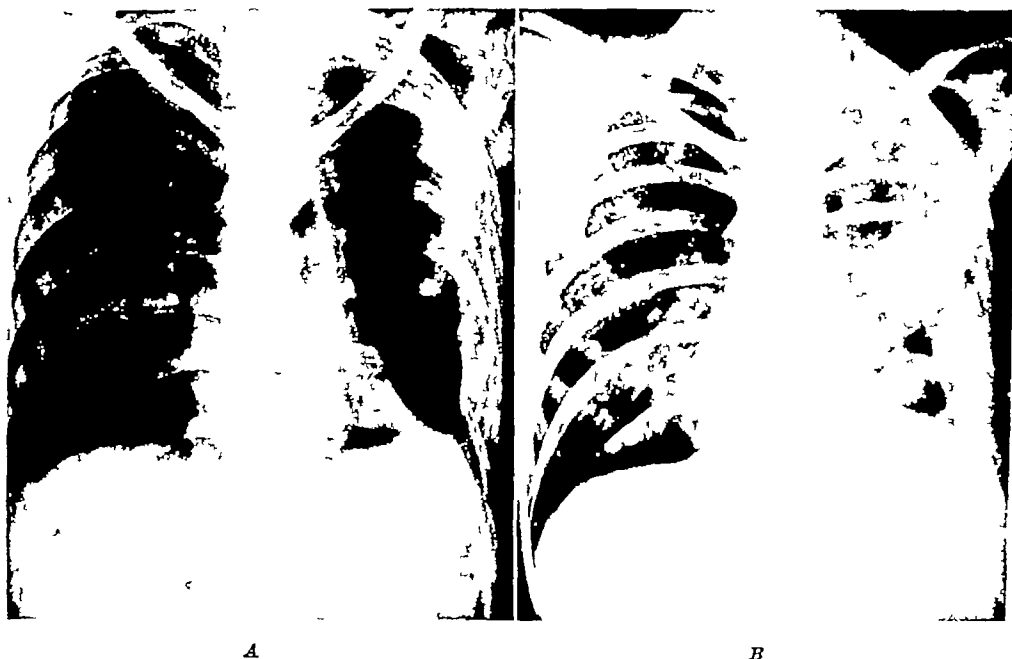


Fig 8—A. A British soldier four months after being wounded with almost a total collapse of the left lung. B. Decortication of the lung was performed. The thickened parietal pleura was not removed. Several holes were made in the lung by the decortication so that although the lung could be expanded at operation it could not be maintained in the expanded state. These small leaks sealed on the third day and the lung re-expanded completely. The roentgenogram was taken five days after operation showing complete re-expansion. The large tube with suction was left in place for about two weeks to be certain that the pleural cavity was obliterated.

At the Thoracic Surgical Center at the Kennedy General Hospital where I was assigned following my return to this country, two men came under my care who had chronic empyemas with considerable collapse of the lung one year after injury (Figs 9 and 10). In each, there was present very thick pleura with empyema cavities of about 150 to 200 c.c. It was obvious that any type of thoracoplasty would result in considerable deformity and in a reduction of functional capacity of the lung. In each instance decortication with re-expansion of the lung was possible. Again a number of lacerations of the lung surface occurred but these became closed in a few days. By the use of high degrees of negative pressure, the lungs were completely re-expanded. Since it was not possible to close the original drainage wound around the tube, the airtight seal described here was helpful in both cases.



A

B

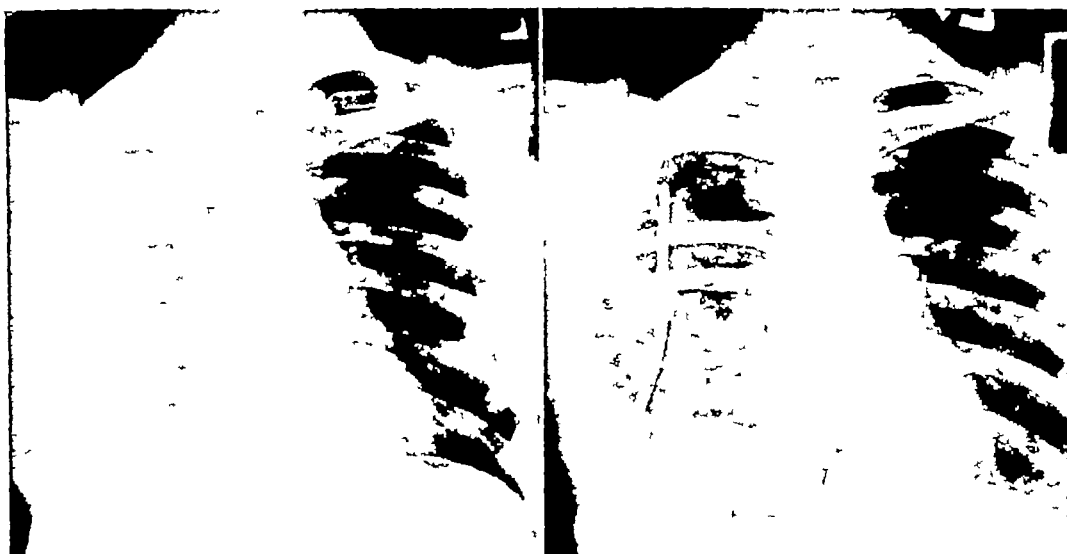
C

Fig. 9—4. A soldier wounded more than one year previous to this X-ray examination. He started out with almost complete collapse of the lung. It gradually re-expanded to the present state. As can be seen the parietal pleura is very thick. The free pleural cavity measured about 150 c.c. There had been no improvement for the past few months. B. A decortication of the lung was performed. The thickened parietal pleura was also removed because of multiple small leaks in the lung. Immediate complete re-expansion of the lung was not obtained. In this instance as can be seen there was some clotting of the fluid in the chest in spite of the application of suction. C. By the use of high degrees of suction through the large ($\frac{3}{4}$ inch) tube which was changed frequently the lung was re-expanded and the pleural cavity completely obliterated. At this time one month after operation the cavity was only the size of the tube.



A

B



C

D

Fig 10—A A soldier wounded more than one year prior to this x-ray examination. He also had had a total collapse of the lung which had gradually re expanded. It had made no progress for several months. There was a thick parietal pleura. The cavity measured 180 c.c. B, Decortication of the lung was performed. The thickened parietal pleura was also removed. This view was taken the day after operation. Because of multiple small tears in the lung it could not be re-expanded immediately. C, The holes in the lung sealed on the fourth day and the lung re expanded. D Three weeks later the lung was completely re expanded. At this time the cavity held only 3 c.c. of fluid in addition to the tube. The tube was then gradually shortened and removed.

We are aware that decortication in these late cases has not always been successful in other hands. Moreover, it will probably not always be successful in our hands. However, if considerable care to detail is exercised when handling these patients, it is believed that success will be attained in most instances. Certainly an attempt to re-expand the lung is justified in those patients in whom considerable thoracoplasties would be required to obliterate the cavity. We believe that it is important to use a large rubber tube ($\frac{3}{4}$ inch) to decrease the danger of its becoming plugged, and to apply a high degree of negative pressure to facilitate re-expansion of the lung, once the small lacerations in the lung surface have become sealed.

Should decortication be done in the presence of a chronic bronchopleural fistula, it would probably be advisable, I believe, that the decortication be complete around the fistula and that the fistulous wall be excised deep into the lung so that normal lung tissue can be closed by suture.

SUMMARY

The fundamental objective in the treatment of battle wounds of the thoracic cavity should be early and complete re-expansion of the lung.

1 Hemothorax is best treated by early repeated thoracentesis to re-expand the lung as completely as possible.

2 Pneumothorax may be treated by early re-expansion with a pneumothorax apparatus. An inter-rib catheter is advisable in the patient with severe tension pneumothorax.

3 Clotted hemothorax should be treated by decortication of the lung with complete re-expansion within the first few weeks.

4 Acute empyema—infected hemothorax may be treated by early decortication and re-expansion of the lung. A large drainage tube with the use of suction is helpful.

5 Sucking wounds of the chest which cannot be closed because of loss of tissue and infection may be handled by means of an airtight seal and suction to re-expand the lung.

6 Chronic empyema with considerable collapse of the lung should be treated by decortication and re-expansion of the lung. The use of high degrees of suction (100 to 150 cm. of water) through a large rubber tube ($\frac{3}{4}$ inch) has been helpful in our experience. The airtight seal described herein may be very useful in those patients in whom it is difficult to close the original drainage wound around the tube. Considerable attention to detail is required in these cases.

REFERENCES

- 1 Churchill, E. D. The Surgical Management of the Wounded in the Mediterranean Theatre at the Time of the Fall of Rome, *Ann. Surg.* 120: 268, 1944.
- 2 Burford, T. H., Parker, E. F., Samson, P. C. Early Pulmonary Decortication in the Treatment of Post-Traumatic Empyema, *Ann. Surg.* 122: 163, 1945.
- 3 Keller, W. L. The Treatment of Chronic Empyema Where the Recognized Surgical Procedures Have Failed to Produce Obliteration, *Ann. Surg.* 76: 549, 1922.
- 4 Hedblom, C. H. The Treatment of Chronic Empyema, *Ann. Surg.* 72: 288, 1920.
- 5 Sanger, P. W. Decortication in Acute Empyema Thoracis, *Surg., Gynec. & Obst.* 82: 71, 1946.
- 6 Kay, E. B. and Meade, R. H. War Injuries of the Chest, *Surg., Gynec. & Obst.* 82: 13, 1946.

ALTERATIONS OF THE BLOOD FOLLOWING INTRATHORACIC OPERATIONS

A CLINICAL STUDY

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SEVERAL studies have shown the extent of blood loss in thoracic operations. White and Buxton,¹ in 1942, by direct measurement estimated a 700 cc blood loss with each stage thoracoplasty and an average of approximately 1,500 cc with pneumonectomy and lobectomy. They advised large transfusions during operation, emphasizing that the extent of blood loss was not generally appreciated. Other blood loss estimates including those of workers² in this laboratory who used blood volume methods have shown comparable results. As a consequence of such studies it is now becoming an established practice in extensive surgery to give preoperative transfusions to the patient if anemia or hypoproteinemia is present, to replace blood as it is lost during operation, and to give postoperative transfusions to the patient as indicated by his clinical state and blood picture. However, the determination of how much replacement therapy is necessary is difficult, indeed, surgical shock may occur before the surgeon realizes that circulating fluid loss has been severe. Collier and his co-workers,³ in an excellent review of blood loss in surgical operations, concluded that direct measurement is necessary in order to know the exact amount of blood loss and therefore the exact amount of blood to replace. However, direct measurement of blood loss is often not practical and the surgeon must rely on knowledge of average losses, the clinical state of the patient and the results of routine blood examinations, the red cell count, the hemoglobin estimation, plasma protein concentration, and the hematocrit.

To assume that there is quantitative relationship between the changes in the hemoglobin, plasma proteins, or hematocrit and the amount of blood loss and using these as a measure for fluid replacement is fallacious as was pointed out by Stewart and Rouke⁴ in 1938. However, Ebert, Stead, and Gibson⁵ in 1941, studying the response of normal subjects to acute blood loss, reported that the hematocrit readings accurately reflected the direction of changes in plasma volume. Thornton, Adams, and Schafer⁶ in this laboratory in 1944 studied plasma protein changes after intrathoracic operation but mentioned that they were unable to correlate entirely hematocrit determinations with the drop in plasma proteins. However, twenty-one of the twenty-nine patients showed postoperative fall in hematocrit and they concluded that replacement therapy must have been inadequate although every effort was made to replace

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with whole blood the exact amount of the estimated loss. It was also noted that the fall in plasma proteins as well as the hematocrit, hemoglobin, and to a lesser extent the red cell count occurred from the third to fifth day following operation. For these reasons it was felt that a careful study of changes in the red cell count, hematocrit, hemoglobin concentration, and blood volumes before and after major thoracic operations might be valuable especially as to their indicating the adequacy or inadequacy of replacement therapy.

METHODS OF STUDY

Repeated erythrocyte counts, and hematocrit and hemoglobin determinations were made pre- and postoperatively in nineteen patients, with seventeen intrathoracic operations and two thoracoplasties. In five of these patients plasma volume and total blood volume determinations were made before and after operation. In all patients, with one or two exceptions, the aim was to replace with whole blood the blood loss as estimated by the surgeon. Patients who showed marked hypoproteinememia or anemia were prepared for operation by preoperative whole blood and plasma transfusions. Blood transfusion was carried on during the operation except in one or two patients and postoperative transfusions were given whenever indicated by the state of the patient or in the face of moderate to severe anemia. The studies were conducted in the following manner. Erythrocyte counts, and hemoglobin and hematocrit determinations were made before operation on all patients. In those patients receiving preoperative transfusion therapy several such determinations were done. In the first five patients daily hematocrit, erythrocyte, and hemoglobin determinations were made until the patient was discharged or preoperative levels were reached and maintained. From these data it was found that erythrocyte counts and other determinations on alternate days were sufficient. In addition to these determinations, plasma volumes were done in five patients: the first determination preoperatively, the second within three hours after the patient had returned from the operating room, and a third determination seven to twelve days following surgery.

Hemoglobin estimation was done by the macro-tube oxyhemoglobin method of Evelyn⁷ using the photoelectric colorimeter. Hematocrits were done by the method of Van Allen^{8, 9} and erythrocyte counts were made in the usual manner. All blood samples were obtained by venipuncture with a minimum of venostasis. The anticoagulant used was heparin. Plasma volumes were determined by the Evans' blue dye (T 1824) technique as described by Gibson and Evans¹⁰ and adapted to the photoelectric colorimeter by the micromethod of Gibson and Evelyn.¹¹ Slight modifications in the method of standardizing the dye and in determining plasma volume were suggested by Schafer¹² of this department. The operations on the nineteen patients studied are classified in Table I.

Two patients had inoperable carcinoma of the lung and one patient had inoperable carcinoma of the cardia extending to the lower esophagus. One patient with extensive carcinoma of the esophagus died on the twenty-seventh postoperative day of peritonitis, one with carcinoma of the cardia died on the

TABLE I CLASSIFICATION OF OPERATIONS IN NINETEEN PATIENTS

OPERATION	NUMBER
Lobectomy	6
Left lower lobe and lingula	4
Right lower lobe	2
Pneumectomy	3
Exploratory thoracotomy	1
Exploratory thoracolaparotomy	2
Transthoracic vagotomy	2
Miscellaneous	5
Resection part of esophagus and esophagogastronomy	2
Thoracoplasty	2
Resection of 3 ribs and part of chest wall and exploratory thoracotomy	1
Total	19

eleventh postoperative day of myocardial infarction, and a third patient with carcinoma of the lung died of bronchial asthma and right heart failure on the second day. All other patients had satisfactorily recovered from the operations by the time the study was completed. Pertinent data on the patients are given in Table II.

The patients are grouped in this table according to the type of operation following the classification given above. Under each of the major headings is listed the hemoglobin in grams per cent, the hematocrit showing percentage of red cell mass in whole blood samples, and the erythrocyte count in millions per cubic millimeter. Under each of these is listed the preoperative status, the lowest postoperative level, the amount of this fall, and the day on which this greatest change was found. Also under the heading, Day Return is listed the day on which postoperative determinations showed return to preoperative levels or, as in many instances where preoperative levels were not reached, the last determination before the study was concluded. In every case these determinations were not discontinued until the blood picture had been stabilized for several days or the patient had been discharged. In many cases complete recovery to preoperative levels had not occurred even though two to three weeks had elapsed. The amount of blood or plasma transfusion is listed as it was given preoperatively, postoperatively, or at the time of the operation. Circumstances which might have significant effect on the blood picture, such as postoperative hemorrhage, infection, or secondary disease, are listed under appropriate columns. Under the group of lobectomy patients averages have been made since the group was sufficiently large and changes sufficiently uniform to make these figures meaningful.

RESULTS

At time of operation nine patients had hemoglobin levels of less than 85 per cent of normal (13.26 Gm per cent) but of these only four had less than 80 per cent (12.48 Gm per cent). Fifteen and six-tenths grams of hemoglobin per 100 cc of blood are arbitrarily taken as 100 per cent. Of these four, one (J. N.) was given a 500 cc whole blood transfusion five days before operation because the initial blood determination showed only 10.06 Gm per cent hemoglobin and a hematocrit of 32.5 per cent. This transfusion effected little change in

the hemoglobin or hematocrit as can be seen from preoperative status in Table II, however, the patient's symptom of severe weakness was improved. He had had marked symptoms and a twenty-eight pound weight loss in the past year.

Two other patients were given preoperative transfusion. D O (see Graph 3), an 8-year-old boy with congenital cystic disease of the lung and symptoms for about one year, had an initial hemoglobin of 8.6 Gm per cent and a hematocrit of 29.6 per cent. Three 300 cc whole blood transfusions in the twenty days before operation resulted in marked improvement of the blood status, the hematocrit going to 41.5 per cent and the hemoglobin to 13.4 Gm per cent. G A (Graph 5) had had a cholecystectomy nineteen days previous to the operation in this study and he was given 450 cc of whole blood two days before this study started. Hemoglobin at the time of operation was 13.2 per cent.

Thornton, Adams, and Schafer⁶ have mentioned the rather surprising observation in a study of hypoproteinemia in thoracic surgery that few patients had marked hypoproteinemia although chronic infection and carcinoma were the most common diseases. In this group of similar patients we can make such a statement regarding grams per cent of hemoglobin, namely, only six patients out of nineteen had less than 80 per cent hemoglobin (12.48 Gm per cent) on initial examination and, as mentioned previously, only four patients had less than 12.48 Gm per cent at the time of operation. This is in contrast to the results of blood status studies in patients with carcinoma or chronic infection in other parts of the body. For example, Oppenheim and associates¹³ reported 64 per cent of patients with carcinoma of the stomach as having abnormally low red cell counts and hemoglobin concentration. It has long been known that there are compensatory changes in the percentage of hemoglobin or red cells in the blood when the oxygen transport capacity of the lung is decreased. Chronic lung disease may therefore account for the fact that most of these patients had a blood status above the anemic level.

In the six patients on whom lobectomies were done the average postoperative fall in the hemoglobin estimation was 2.1 Gm per cent and the average of the days on which this lowest fall was found was 5.2 days. The range was 6 to 4.0 Gm and three to eight days. This is approximately true for all the patients in this series, although in general the patients with first stage thoracoplasty and those in whom there was extensive resection, as in Patient C K, the drop in gram per cent of hemoglobin was somewhat greater. Only one patient, J N, showed no fall after operation and he was given 1,600 cc whole blood during operation, which was considered more than adequate replacement of the estimated blood loss.

In only two patients in the series had the preoperative hemoglobin level been reached by fourteen days postoperatively, one of these was J N, in whom no drop occurred, and the second, B G (see Graph 2), maintained this level of hemoglobin for only one week, then it again dropped below preoperative levels during the final week before she died on the twenty-seventh day.

Although the average day of lowest hemoglobin determination in the lobectomy patients is 5.2, it was observed that the greatest per cent of this

TABLE II

PATIENT, SEX AND AGE	DIAGNOSIS	OPERATION	INFECTION	WHOLE BLOOD TRANSFUSION	REMARKS
<i>Miscellaneous</i>					
1 B G, F, 62	Carcinoma of esophagus	Resection of lower $\frac{2}{3}$ of esophagogastronomy and splenectomy	Yes	1,500 c.c. at operation	Patient died of peritonitis 27 days P O
2 I W, M, 68	Carcinoma of cardia	Esophagogastronomy	No	1,500 c.c. at operation	Patient died of myocardial infarction on 11th day P O
3 M W, F, 41	Pulmonary tuberculosis	Thoracoplasty, Stage I	No	500 c.c. at operation, 500 c.c. on 4th P O day	Patient had severe hemorrhage into wound immediately after operation
4 H C, F, 41	Pulmonary tuberculosis	Thoracoplasty, Stage I	No	1,000 c.c. at operation	-----
5 C K., M, 55	Carcinoma of lung extending to chest wall	Resection of 3 ribs and exploratory thoracotomy	No	1,000 c.c. at operation	-----
<i>Pneumonectomy</i>					
1 J N, M, 64	Carcinoma	Pneumonectomy of right lung	No	500 c.c. before operation, 1,600 c.c. at operation	-----
2 M B, F, 45	Sarcoma	Pneumonectomy of left lung	No	1,000 c.c. at operation	-----
3 H W, M, 54	Carcinoma	Pneumonectomy of right lung	No	1,500 c.c. at operation	Died on 2nd P O day of bronchial asthma and right heart failure
<i>Exploratory Thoracotomy</i>					
1 H B, M, 53	Carcinoma, left lung, inoperable	Exploratory thoracotomy	No	550 c.c. at operation	Inadequate replacement therapy
2 G A, M, 61	Carcinoma, stomach, inoperable	Exploratory thoracotomy	No	450 c.c. before operation, 500 c.c. at operation	Inadequate replacement therapy
3 M L, M, 59	Carcinoma, cardia, inoperable	Exploratory thoracotomy	No	500 c.c. at operation	Inadequate replacement therapy

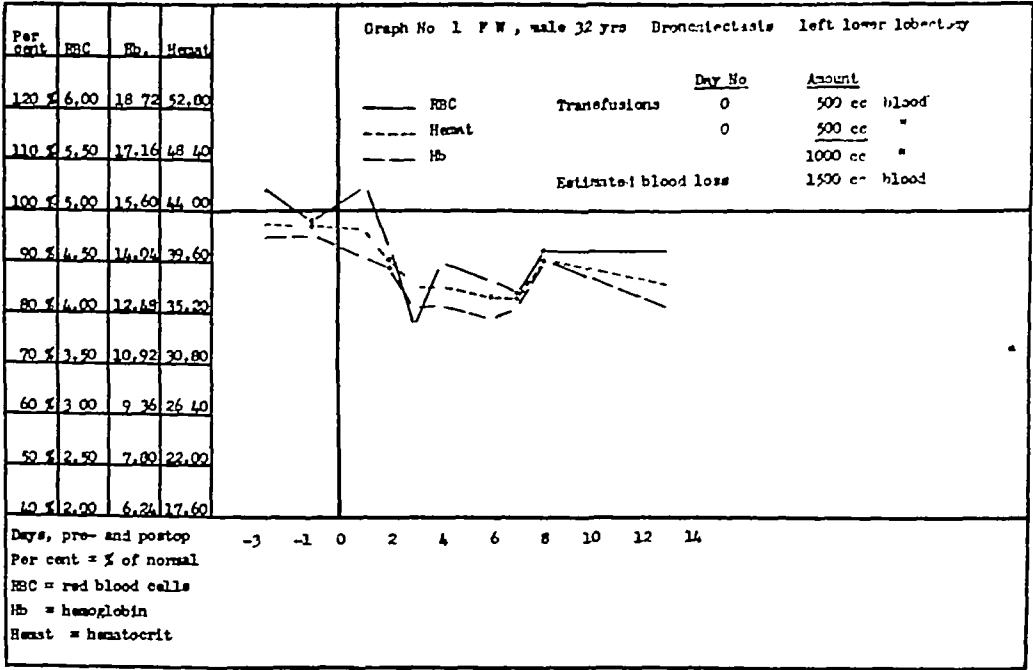
than did the hemoglobin and hematocrit in which 15.6 Gm per cent and 44 per cent were considered as average normal figures. The figure of 15.6 Gm per cent as equal to 100 per cent is probably higher than the figure more commonly accepted and were this "normal" lowered the difference would only be accentuated. Also, since three of the exceptions to this statement are women and a more normal figure for them would be 4.5 million red cells, one can even say that in 75 per cent of the patients studied the red cell count reflects a better blood status than does the hemoglobin or hematocrit. Examples of this are seen in Graphs 3, 4, and 5.

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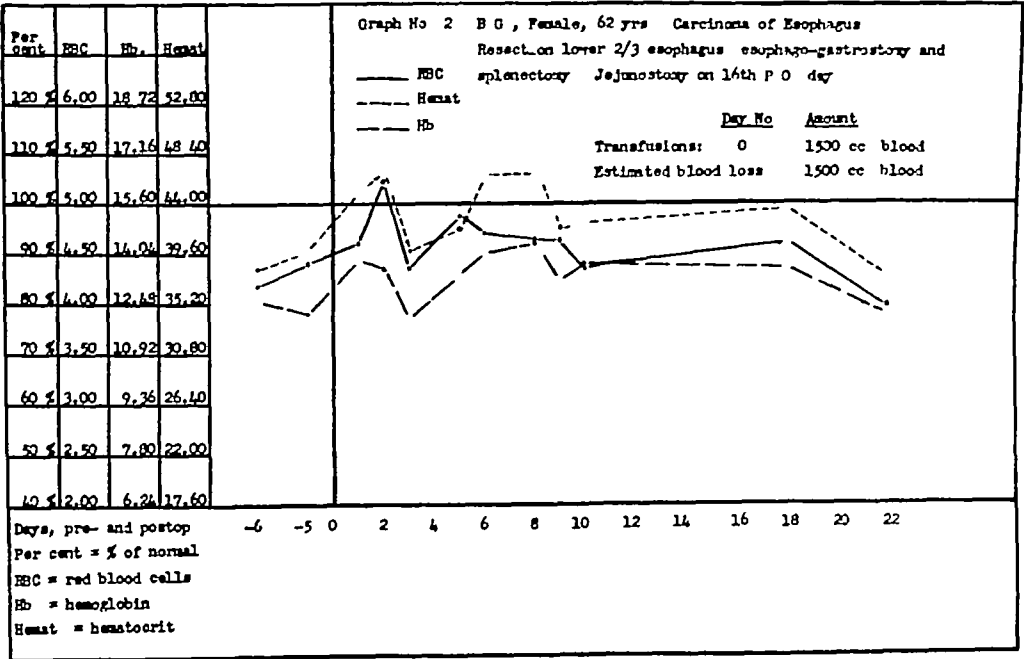
HEMOGLOBIN (GM %)					HEMATOCRIT (% OF TOTAL BLOOD)					ERYTHROCYTE COUNT (MILLIONS PER CU MM)				
PRE- OPER ATIVE	FALL	POST OPER ATIVE	DAY FALL	DAY RE TURN	PRE OPER ATIVE	FALL	POST OPER ATIVE	DAY FALL	DAY RE TURN	PRE OPER ATIVE	FALL	POST OPER ATIVE	DAY FALL	DAY RE TURN
(5)														
12.3	3	12.0	3	13.3 on Day 5	39.9	--	39.9 on Day 3	--	37.3 on Day 22	4.42	.08	4.34	3	3.96 on Day 22
12.8	1.4	11.5	6	11.5 on Day 6	38.2	--	39.1 on Day 4	--	34.7 on Day 6	4.62	--	5.31 on Day 4	--	3.71 on Day 6
13.5	6.4	7.1	3	11.3 on Day 10	39.9	17.4	22.5	3	35.3 on Day 10	5.70	2.87	2.83	3	4.07 on Day 10
13.3	3.1	10.2	10	--	42.2	10.1	32.1	3	--	4.68	.94	3.74	3	4.03 on Day 10
13.3	4.6	8.7	4	10.2 on Day 8	37.9	11.5	28.4	4	32.1 on Day 8	4.37	1.62	2.73	4	3.64 on Day 8
(3)														
10.3	No fall	12.9 on Day 3	--	--	32.6	No fall	40.4 on Day 3	--	--	4.23	No fall	4.92 on Day 3	--	--
13.2	2.6	10.6	11	12.1 on Day 18	40.2	7.9	32.3	1	35.6 on Day 18	4.68	.87	3.81	7	4.03 on Day 18
13.6	1.1	12.5 on Day 1	--	--	40.5	No fall	46.4 on Day 1	--	--	4.52	No fall	4.70 on Day 1	--	--
and Thoracotomy (3)														
12.0	7.0	11.3	11	--	38.8	2.4	36.4	4	37.4 on Day 11	4.60	.13	4.47	1	4.66 on Day 11
13.2	2.4	10.8	3	11.0 on Day 10	38.3	4.4	33.9	3	34.2 on Day 11	4.01	--	4.17	--	4.75 on Day 10
13.2	2.5	10.7	7	--	40.9	7.9	33.0	1	34.7 on Day 7	5.62	1.39	4.23	7	

One patient, M W (see Graph 6), showed the greatest postoperative fall in hemoglobin, hematocrit, and erythrocyte count, respectively, a fall of 6.4 Gm per cent, 17.4 per cent, and 2.87 million, so that on the third postoperative day the patient's blood status was 7.1 Gm per cent of hemoglobin, 22.5 per cent hematocrit, and 2.83 million red cell count, and it must be emphasized that the cause of this severe drop was hemorrhage into the operative wound. The three patients undergoing exploratory thoracotomy were given an average of 500 cc whole blood at operation and, although in the absence of extensive resection blood loss is not so great as in some of the other operations listed,

the surgeon felt that each of these had had inadequate replacement to restore the blood to a normal status. The two patients with transthoracic vagotomy received no blood at operation. However, no greater change of blood status was observed in these two patients than in others and it must be concluded

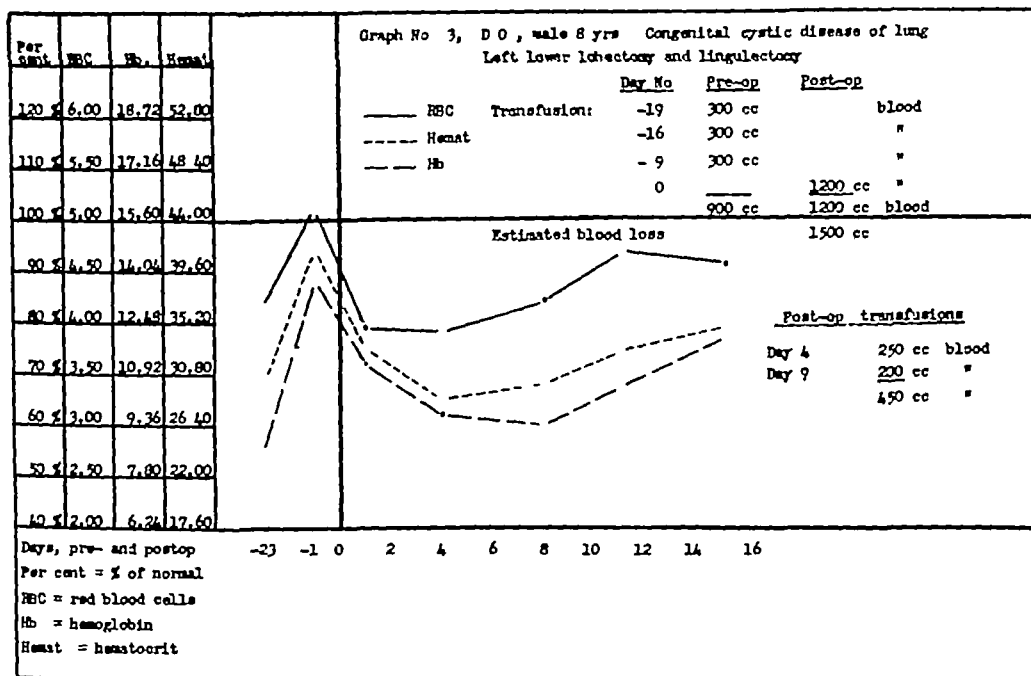


Graph 1

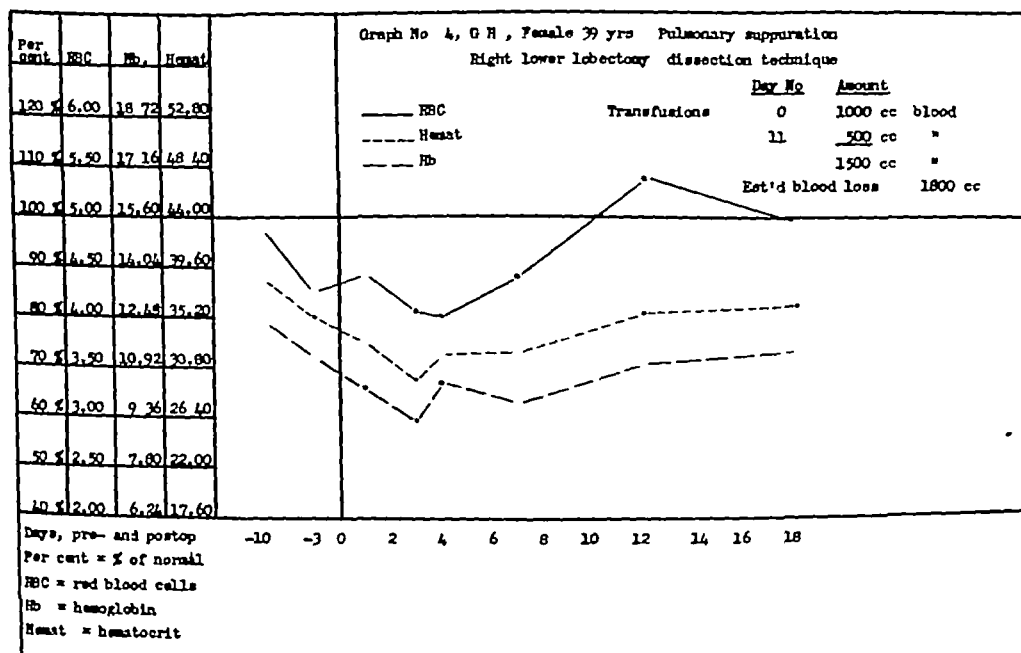


Graph 2

that these patients were no more seriously undertreated as far as replacement therapy is concerned than were other patients who had more extensive operations and larger transfusions



Graph 3



Graph 4

Graph No 5, O A. Male 61 years Carcinoma of the stomach
Exploratory thoraco-laparotomy

Per cent RBC Hb. Hemat

120	6.00	18.72	52.80
110	5.50	17.16	48.40
100	5.00	15.60	44.00
90	4.50	14.04	39.60
80	4.00	12.48	35.20
70	3.50	10.92	30.80
60	3.00	9.36	26.40
50	2.50	7.80	22.00
40	2.00	6.24	17.60

Pay No Amount

_____ RBC Transfusions -C *450 cc blood - Patient had a cholecystec-
 ----- Hemat 0 500 cc " tory on 1-18-45 (3 weeks
 ----- Hb before this operation)

Est'd blood loss 1000 cc "

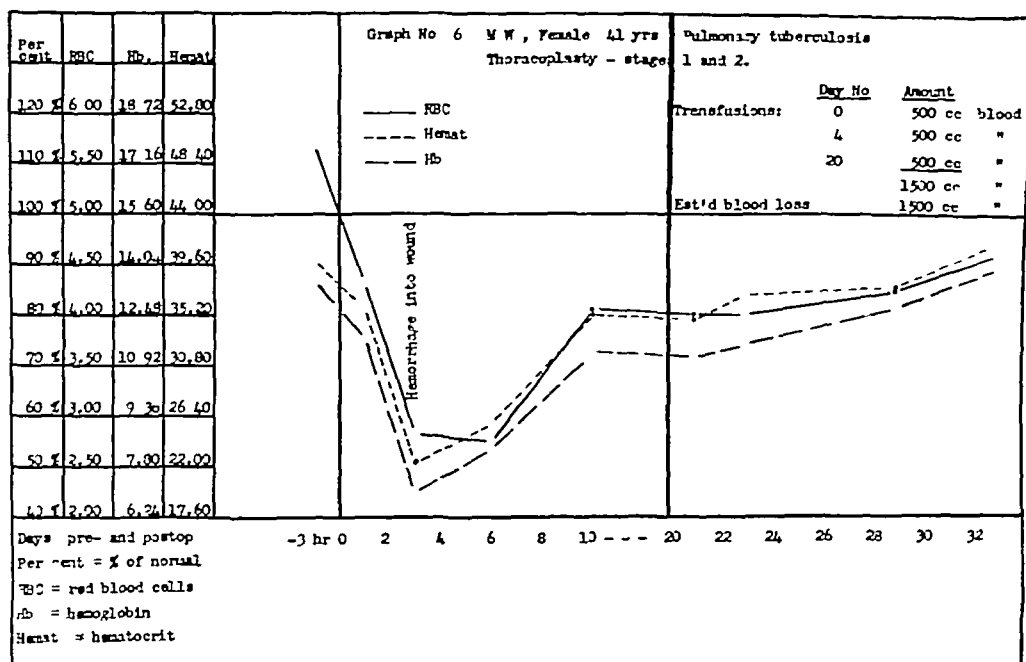
* This 450 c c blood given 2 days before this study began

Days pre- and postop -6 -1 0 2 4 6 8 10

Per cent = % of normal

RBC = red blood cells
 Hb = hemoglobin
 Hemat = hematocrit

Graph 5



Graph 6

namely, $\frac{2}{25}$ of body weight with a normal hematocrit of 45 per cent. Plasma volume, cell volume, and total volume are listed as determined preoperatively, immediately postoperatively, and again seven to twelve days later. The amount of transfusion at the time of operation is given. The hematocrit is listed as determined at the time of the determination of all the blood volumes. Two blood volumes determined immediately after operation are not included because of technical mistakes. The first three patients have basal volumes within 500 c.c. of the estimated volume. The fourth patient's basal volume is 2,167 c.c. below basal volume. The only explanation for this might be the fact that this patient was dehydrated by forty-eight hours of continuous gastric aspiration before the basal volume was determined. Note that the hematocrit determined at this time was 53.3 per cent, the hemoglobin 17.6 Gm. per cent, and the red cell count 6.4 million as seen in Table II. The fifth patient's basal volume is 880 c.c. below estimated volume and there is no known reason for this difference.

In the second part of Table III are listed the differences between preoperative volumes and postoperative volumes as found in the immediate volume determinations and determinations seven to twelve days later. In the first patient the total volume as determined immediately after operation dropped 1,445 c.c. and with 500 c.c. whole blood transfusion at time of operation added this would mean a total blood loss of 1,945 c.c. This patient had an exploratory thoracotomy with no resection and the surgeon estimated a 1,200 c.c. blood loss. In the third patient the determined loss was 1,349 c.c. and no transfusion was given at operation. The fourth patient showed a loss of only 386 c.c. This was the patient who showed marked hemoconcentration before the operation. Note that ten days later when his third plasma volume was determined there was an increase of 795 c.c. over the first plasma volume determination. However, the red cell volume deficit at ten days was 647 c.c., therefore, the total blood volume increase was only 148 c.c.

By seven to twelve days after operation there was, without exception, an increase in plasma volume over the basal plasma volume. This varied from 291 to 795 c.c. There was a fall in red cell volume ranging from 208 to 914 c.c. by seven to twelve days. Hematocrit fall during this time varied from 3.4 to 17.9 per cent, the latter in the fourth patient, who had shown the marked hemoconcentration before operation.

DISCUSSION

Blood loss and its restoration, especially following major surgery in patients with serious disease, is an exceedingly complex physiologic mechanism involving hemopoiesis, protein and electrolyte metabolism, maintenance of an adequately circulating fluid volume, and the hemostatic forces which the body can muster to minimize as much as possible the slow chronic loss of cells and plasma into large operative wounds. That the loss of bloody serum may be of considerable importance, especially when postoperative aspiration is used, has been shown by Thornton, Adams, and Schafer,⁶ who found an average loss of 673.3 c.c. serum in twelve patients on whom lobectomies were done. The

TABLE III BLOOD VOLUME DETERMINATIONS BEFORE

PATIENT AGE AND SEX	DIAGNOSIS	OPERATION	WEIGHT (KG)	ESTIMATED BLOOD VOLUME (C C)	PREOPERATIVE BLOOD VOLUMES		
					PLASMA VOLUME	CELL VOLUME	TOTAL VOLUME
1 G A, M, 61	Carcinoma of stom- ach, inop- erable	Exploratory thoraco- laparotomy	68.5	5,480	3,114	2,033	5,147
2 M L., M, 59	Carcinoma of cardia, inoperable	Exploratory thoraco- laparotomy	67.5	5,400	2,935	2,031	4,966
3 M S., M, 42	Stomal ulcer, re- current	Transthoracic vagotomy	66.0	5,280	3,065	2,507	5,572
4 G P., M, 49	Stomal ulcer, re- current	Transtho- racic vagotomy	75.6	6,048	1,824	2,057	3,881
5 C F., M, 30	Bilateral bronchiec- tasis	Left lower lobectomy and lingul- ectomy	66.2	5,296	2,561	1,855	4,416

*Difference Between Preoperative Volumes, Immediate Postoperative Volumes,
and Postoperative Volumes 7 to 12 Days*

PATIENT	PLASMA VOLUME	CELL VOLUME	TOTAL VOLUME	PLASMA VOLUME	CELL VOLUME	TOTAL VOLUME	HEMATOC- RIT (%)
G A	-952	-493	-1,445	+291	-208	+ 83	3.4
M L	-	-	-	+470	-222	+248	6.2
M S	-509	-838	-1,349	+482	-914	-432	14.1
G P	+252	-638	- 386	+795	-647	+148	17.9
C F	-	-	-	+443	-238	+205	7.5

*Detailed studies of the blood volume before and following intrathoracic operations in five patients. The immediate postoperative studies in the second and fifth patients were incomplete. The increase or decrease in plasma volume, cell volume and total volume are indicated below. It is apparent that the decrease in all values occurs immediately following operation in spite of the fact that the patients received from 500 to 1,000 c.c. of whole blood for replacement of blood loss. The studies from seven to twelve days following operation show that this deficit was made up chiefly by plasma from the tissues, the turn of cell volume to the preoperative level requiring a considerably longer period of time.

hemoglobin concentration of this serum may be as high as 7 to 8 Gm per 100 c.c. In order to evaluate these changes and thereby properly treat the patient, the surgeon has at his hand the practical technique of counting red cells, determining hemoglobin and plasma protein concentration, estimating blood loss, and critically judging the patient's clinical response to intravenous treatment before and after operation. Accurately measuring blood loss or determining pre- and postoperative blood volumes is not usually practical.

This study emphasizes that even with seemingly adequate blood replacement the patient's blood does not maintain an even status after major thoracic surgery. The average drop in hemoglobin in grams per cent in these patients was 2.1 Gm. and in most patients this drop had not been restored by the end of two to three weeks following operation. It has already been mentioned that most of these patients showed little or no change in the twenty-four hour period immediately after operation. There seem to be two important factors accounting for this minimal change twenty-four hours postoperatively. First, there is a decreased circulating blood volume with vasoconstriction and vary-

FOLLOWING INTRATHORACIC OPERATIONS IN FIVE PATIENTS*

REPLACE MENT (C.C. BLOOD)	IMMEDIATE POSTOPERA TIVE BLOOD VOLUMES			POSTOPERATIVE BLOOD VOLUMES, 7 TO 12 DAYS			HEMATOCRIT		
	PLASMA VOLUME	CELL VOLUME	TOTAL VOLUME	PLASMA VOLUME	CELL VOLUME	TOTAL VOLUME	PREOP ERATIVE	IMMEDI ATE POST OPERATIVE	POSTOP ERATIVE (7 12 DAYS)
500	2,162	1,540	3,702	3,405	1,825	5,230	38.3	41.6	34.9
500	-	-	-	3,405	1,809	5,214	40.9	34.7	34.7
0	2,554	1,669	4,223	3,547	1,593	5,140	44.8	39.5	30.7
0	2,076	1,419	3,495	2,619	1,410	4,029	53.3	40.6	35.4
1,000	-	-	-	3,004	1,617	4,621	42.4	43.1	34.9

ing degrees of hemoconcentration or hemodilution, and, second, there is the immediate effect of transfusions given at operation which for a transitory period tend to hold blood status at its preoperative level. After this, however, the level of oxygen carrying constituents of the blood may show a relative fall during the next five or six days. This is produced by an increase in circulating volume and the gradual loss of cells and plasma continuing to seep into the operative wound. Ebert, Stead, and Gibson⁵ in 1941 carefully studied the changes in circulating volume and blood constituents during a period in which 15.5 to 19.7 per cent of the total blood volume was drawn by phlebotomy from six normal, healthy, professional blood donors. They were able to show that plasma volume began to increase immediately after blood loss and that its return was apparently governed by the ability of the body to supply plasma protein to the circulating fluid. In normal healthy individuals, in surgical patients whose plasma protein stores are not markedly decreased due to their disease, or in patients whose preoperative treatment has been effective in restoring protein metabolism to approximately normal, the restoration of total circulating fluid and total circulating protein is often a relatively rapid process. Thus, Ebert, Stead, and Gibson⁵ found total circulating blood volume returned approximately to preblood loss levels by seventy-two hours and Thornton, Adams, and Schaffer⁶ found plasma protein concentration returned to preoperative levels by 90 days in patients undergoing major intrathoracic operations and to whom blood transfusions were given when deemed necessary. It is not surprising to find, however, a somewhat different picture when changes in red cell volume and hemoglobin are examined. There are no significant red cell reservoirs in man and restoration of red cell volume and hemoglobin concentration after blood loss lags behind the restoration of plasma protein concentrations and the plasma volume. The

results of our plasma and red cell volume determinations substantiate this view. At the end of seven to twelve days postoperatively, the red cell volume is less than preoperative red cell volumes, this deficit varying from 208 to 914 c c.

Ebert, Stead, and Gibson⁵ found in their study that the lowest hematocrit was obtained within twenty-four hours of phlebotomy. Results in surgical patients differ from their experiments in two ways, first, there is whole blood transfusion at the time of blood loss and, second, there is, postoperatively, continued plasma and red cell loss into the operative site. For these reasons the lowest level reached as far as red cells are concerned may not be until three to seven days after the operation.

In most clinics, including our own, the determination to give pre- or post-operative blood transfusions is most often made on the basis of routine blood examinations, namely, the red cell count and the hemoglobin concentration, qualified, of course, by the clinical state of the patient. Thus, much depends on the accuracy of these determinations and the interpretation of accurate results. It has already been pointed out that a normal hemoglobin concentration, red cell count, or hematocrit twenty-four hours after operation may be entirely misleading as to the course of changes to come in the patient's blood status. Our studies would indicate that such determinations be made at least every other day for one week, or more often if the blood change is greater than expected on any one determination. Graph 6 shows how markedly the blood status can change because of hemorrhage and this was unsuspected until the blood determinations were made.

In our surgical service hematocrit determinations are not routinely done. Red cell counts and hemoglobin estimations are done by students who are in their third year clerkships and these determinations are routinely made every one to two days for about one week after major operations and thereafter as indicated. The red cell count is made in the usual manner and the hemoglobin estimation is done with the Sahli instrument in which acid hematin (in a calibrated tube) is diluted until a color match is obtained with a similar sized brown glass rod.

Wintrobe¹⁴ said " that hemoglobin of the blood is as a general rule determined with less care and by methods which are more inaccurate than those for the determination of any other constituent of the body " and he listed most of the methods for estimating hemoglobin and gave a critical analysis of these various methods. Karr and Clark¹⁵ in 1941 reported a comparison of various hemoglobin methods as performed by technicians and doctors in several hospitals and clinics. They pointed out the well-known sources of error in direct colorimetry such as inaccuracy of the instrument and the variability of the human factor in being able to match accurately red or brown colors. Their results show that at least two Sahli instruments in their clinics were inaccurately calibrated to the extent of 1 Gm hemoglobin or more. Further, and this is of even more importance, they showed that the physicians erred in hemoglobin estimation to the extent that only 71 per cent of their determinations fell within 1 Gm of the true hemoglobin concentration. This

error was after corrections for inaccurately calibrated instruments were made. True hemoglobin concentration was determined by the Sheard-Sanford photometer and Van Slyke O₂ capacity methods. In fact, Evelyn⁷ reported an accuracy of plus or minus 2 per cent with the photoelectric colorimeter which, as mentioned earlier, is the method by which hemoglobin concentration was determined in this study.

During the course of this study we have checked at random approximately ten students in twenty-seven hemoglobin estimations with the Sahli instrument and have found results comparable to those of Karr and Clark. Only 41 per cent of the determinations by the students were within 1 Gm of the true hemoglobin estimation, 66 per cent within 2.0 Gm, and only 88 per cent within 3 Gm. No attempt was made to calibrate the Sahli instruments now in use in our clinic. The average mean deviation by the student was 1.23 Gm and the greatest deviations were plus 3.04 Gm and minus 1.20 Gm, a range of 4.24 Gm or approximately 25 per cent of the normal hemoglobin concentration. No emphasis need be drawn to the uselessness or, in fact, to the dangers of such inaccurate determinations and no list of the factors which are responsible for these errors need be made.

Such errors as have been pointed out for the Sahli hemoglobinometer are not, however, unique to that instrument, as all other instruments of direct colorimetry are more or less likewise inaccurate.

At the present the erythrocyte count enjoys considerable popularity as a means of determining blood status but it is common knowledge that even in the hands of technicians individual counts may vary by as much as 500,000 red cells or roughly 10 per cent of the normal red cell count. The mean deviation in the hands of unskilled students is probably this much or more. Certainly the surgeon who bases his transfusion therapy on such determinations should be acutely aware of the magnitude of the possible error. Of as much or more importance in criticizing the red cell count as a valuable and critical adjunct in the determination of the blood status in patients undergoing major thoracic surgery and large whole blood transfusions is the factor brought out in the earlier discussion of this study, namely, that the red cell count even when carefully done in a uniform manner with similar samples of blood tends to be erratic and, in general, gives a more optimistic picture of the blood status than is warranted by accurate hemoglobin or hematocrit determinations. Our results substantiate those of Dieckmann,¹⁷ who found an error of as much as 13.7 per cent in the results of routine red blood cell counts while the error in hematocrit determinations was only 2.0 per cent.

The hematocrit was determined in this study by the use of Van Allen's^{8, 9} capillary tubes and we had little or no technical difficulty with this method. There are, however, two or three important sources of error in the determination of the hematocrit and unless these are avoided the hematocrit determination can be as valueless, as has been pointed out, as is the erythrocyte count or the hemoglobin estimation by the more common methods. One of the chief errors in this regard is the improper choice of anticoagulant. It is

well known that the sodium and potassium oxalate salts often used as anti-coagulants may change the red cell size by as much as 4 or 5 per cent. Accurate correction for this effect is difficult and may be one of the reasons why the hematocrit has gained as slowly in favor as it has. This difficulty is, however, easily solved by using minute amounts of heparin, which was suggested as an anticoagulant for the hematocrit determination by Mason¹⁶ as long ago as 1924. We have not experimentally compared the various micro- and macro-sized instruments for the hematocrit determination, but from the literature it seems apparent that with sufficient centrifugalization all the methods are quite comparably accurate so long as consideration is given to the anti-coagulant. Realizing that it has not been practical to make routine use of the photoelectric colorimeter for hemoglobin determination we must therefore conclude that of the commonly used techniques the hematocrit determination is the most valuable aid to the surgeon in determining pre- and post-operative blood status. In patients undergoing major thoracic surgery and treated with relatively large whole blood transfusions the greatest changes in blood status occur from the second to the fifth days. During this period the blood picture should be most carefully followed.

SUMMARY AND CONCLUSIONS

The changes in red cell count, hemoglobin estimation, and hematocrit were followed pre- and postoperatively in patients undergoing major thoracic surgery. It was found that even with blood transfusion aimed at replacing the estimated amount of blood lost at operation, values for all of these determinations dropped by as much as 10 to 15 per cent after the operation. The greatest amount of this fall occurred during the second to fifth days after operation.

The changes in hemoglobin estimation and hematocrit were found to parallel each other closely, but the red cell count was erratic and, in general, gave a more optimistic picture of the blood status than was warranted by the hematocrit or hemoglobin estimation. Of these latter two routine methods of determining blood status, the hematocrit is the most valuable both in terms of the technical ease of obtaining accurate determinations and its reliability in following changes in blood status, since gross errors in hemoglobin estimation are obtained with direct colorimetry methods.

In a series of five patients, blood volumes were determined before and after operation. In all, the blood volume was decreased immediately after operation. In every case, with one exception, the total blood volume had returned to its preoperative level by seven to twelve days after operation. This return to preoperative level was due to an increase in plasma volume over and above the preoperative plasma level. The total cell volume showed a deficit varying from 208 to 914 cc. at seven to twelve days after operation.

It was observed in this study of patients, who for the most part were suffering from chronic lung diseases, that few of them had anemia. Such an observation has been made before in similarly diseased patients and this is

apparently explained by the well-known fact that interference with the oxygen transport function of the lung results in compensatory changes in the blood status

REFERENCES

- 1 White, M L, and Burton, R W Blood Loss in Thoracic Operations, *J Thoracic Surg* 12 198, 1942
- 2 Allen, J Garrett, Clark, D E, Thornton, T F, Jr, and Adams, W E The Transfusion of Massive Volumes of Citrated Whole Blood and Plasma in Man Clinical Evidence of Its Safety, *SURGERY* 15 824, 1944
- 3 Collier, Frederick, A, Crook, Clarence E, and Iob, Vivian Blood Loss in Surgical Operations, *J A M A* 126 1, 1944
- 4 Stewart, J D, and Rourke, G M. Changes in Blood and Interstitial Fluid Resulting From Surgical Operations and Ether Anesthesia, *J Clin Investigation* 17 413, 1938
- 5 Ebert, R V, Stead, E A, Jr, and Gibson, J G, Jr Response of Normal Subjects to Acute Blood Loss, *Arch Int Med* 68 578, 1941
- 6 Thornton, T F, Jr, Adams, W E, and Schafer, P W Hypoproteinemia in Thoracic Surgery, *Surg, Gynec & Obst.* 79 368, 1944
- 7 Evelyn, K A A Stabilized Photoelectric Colorimeter With Light Filters, *J Biol Chem* 115 63, 1936
- 8 Van Allen, C M An Hematocrit Method, *J Lab & Clin Med* 10 1027, 1925
- 9 Van Allen, C M Sealing Device for Hematocrit, *J A M A* 85 2033, 1925
- 10 Gibson, J G, Jr, and Evans, Wm A, Jr Clinical Studies of Blood Volume, *J Clin Investigation* 16 301, 1937
- 11 Gibson, J G, Jr, and Evelyn, Kenneth A Clinical Studies of Blood Volume, IV Adaptation of Method to Photoelectric Microcolorimeter, *J Clin Investigation* 17 153, 1938
- 12 Schafer, P W Personal communication
- 13 Oppenheim, A, Abels, Jules, C, Pack, Geo T, and Rhoads, C P Metabolic Studies in Patients With Cancer of the Gastrointestinal Tract, *J A M A* 127 273, 1945
- 14 Wintrobe, M M Tice's Practice of Medicine, Hagerstown, Md, 1944, W F Prior Company, Inc
- 15 Karr, W G, and Clark, J H Comparison of Various Hemoglobin Methods as Performed in Hospital and Physicians Laboratories, *Am J Clin Path (Tech Supp)* 5 127, 1941
- 16 Mason, E C Blood Coagulation The Production and Prevention of Experimental Thrombosis and Pulmonary Embolus, *Surg, Gynec & Obst* 39 421, 1924
- 17 Wolff, John R, and Lumarzi, Louis R Anemia in Pregnancy, *J A M A* 128 482 489, 1945 (Discussion by Dieckmann, p 489)

EXPERIMENTAL APPENDICAL PERITONITIS

I THE PROGNOSTIC SIGNIFICANCE OF CERTAIN HEMATOLOGIC FACTORS, ESPECIALLY THE PROTHROMBIN TIME

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INTRODUCTION

THE mechanism of death in appendical peritonitis has been generally assumed to be related to the consequences of the growth within the peritoneal cavity of a variety of intestinal bacteria, chiefly *Escherichia coli*, intestinal streptococci, and Clostridia, with liberation of toxins capable of producing not only local injury, but systemic lesions as well. During the period since the introduction of new chemotherapeutic agents there has been observed a definite reduction in mortality from this disease, but considerable uncertainty has remained as to whether the apparent reduction is due to chemotherapy or to improvement in ancillary methods of treatment, such as maintenance of requirements of fluid, electrolyte and blood, and intestinal decompression. It has been well recognized that the bacteria most frequently found in appendical peritonitis are comparatively insusceptible to the effects of sulfonamides and, to an even greater degree, of penicillin. Therefore, the recent report of Fauley, Duggan, Stormont, and Pfeiffer,¹ suggesting marked benefit from penicillin in experimental appendical peritonitis in the dog, now confirmed by Ravdin and Frank,² made it desirable to attempt to define more precisely the basis of chemotherapy in peritonitis. Because of the importance of peritonitis as a cause of death in penetrating wounds of the abdomen, it was decided that this was a problem of sufficient wartime importance to justify an immediate investigation. It was hoped that advantage might be taken of new advances in our understanding of the basis for the morbid changes in other related diseases such as traumatic shock and burns.

Fauley and his colleagues reported a mortality of 92.6 per cent in control animals in which peritonitis was produced by ligation and subsequent necrosis of the appendix. There was no mortality from peritonitis in animals in which penicillin treatment was commenced immediately after application to the appendix of the peritonitis-inciting ligature, providing animals dying of internal fecal fistula were excluded. The corresponding figures obtained by Ravdin and Frank were 90 per cent and 30 per cent, respectively. In both series, there seemed to be little doubt as to the protective action of penicillin. However, the protective effect of penicillin in peritonitis has not been related

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exclusively to a direct bactericidal or bacteriostatic action of the drug. That other mechanisms may be involved in the protective action of penicillin has been clearly demonstrated by Boon and Miller.³

The plan of our investigation was to produce peritonitis in dogs by the same technique used by Fauley and associates, and then to carry out on the animals a variety of biochemical and physiologic measurements in the hope of finding some critical variation between dying and surviving animals which might logically be influenced directly by specific treatment with penicillin or other agents. The work of several previous investigators had provided some useful guides in planning the scope of the study and selecting the techniques to be employed in arriving at the desired goal.

Studies carried out by Bower and his colleagues^{4, 5, 6} led to the conclusion that the toxins of *Clostridium welchii* were largely responsible for the lethality of peritonitis. He claimed that plasma from a recovering animal would not only protect another animal from the disease, but would also protect the pigeon against *Cl. welchii* toxin. The occurrence of *Cl. welchii* in the peritoneal exudates of patients in his clinical series was substantially higher than that reported by other observers. If the interpretation by Bower and associates is correct, the action of penicillin might be accounted for on the basis of a drug-induced inhibition of the activity of *Cl. welchii*.

Meleney, Harvey, and Jern,⁷ after a study of 106 cases of peritonitis, concluded that *Esch. coli* and streptococci were of equal or greater importance than *Cl. welchii* in the lesions of peritonitis, and showed that the latter organism was frequently absent from lesions in fatal cases. These and other authors have emphasized the importance of bacterial synergism in peritonitis. However, assigning to any or all of these bacteria the lethal role in peritonitis still leaves the picture incomplete. It remains important to obtain an understanding of the physiologic and biochemical abnormalities which, although perhaps induced by bacterial toxins, are in the last analysis responsible for morbidity and death.

Evidence that disturbances in hemodynamic equilibrium are of importance in peritonitis can be found in reports of Elman⁸ and of Scudder and co-workers,^{9, 10} based largely on laboratory studies in patients. Elman reported on the successful use of plasma in cases of peritonitis on the basis that peritonitis is associated with marked reduction in circulating blood volume. In attempting to maintain globulin and albumin at normal levels throughout the course of the disease he used as much as 1,000 cc of plasma per day, with apparently favorable results. Scudder suggested that the success of therapy in peritonitis (and in some other surgical diseases) could be related to the adequacy with which hydration, electrolyte balance, and protein levels were maintained, and that the use of frequent measurement of the specific gravity of whole blood and of plasma is distinctly helpful as a guide in replacement therapy. This study indicated that the disease is associated with physical changes in blood which were interpreted as representing dehydration and hypoproteinemias, and that correction of these factors results in clinical im-

provement There can be no doubt that peritonitis results in the loss into the bowel and into the free peritoneal cavity of considerable amounts of water, protein, and electrolytes, with a concomitant reduction in blood volume

The observations of Altemeier and Jones¹¹ and of Bisgard and associates¹² concerning the influence of prophylactic x-ray treatment on the resistance of animals and patients to peritonitis seemed possibly relevant to our study It does not appear that any adequate explanation has ever been advanced for the apparent protective effect of roentgen irradiation of the abdomen, particularly for the presence of a protective antitoxic factor as identified by Bisgard in the circulating plasma of animals exposed to small doses of x-rays

The foregoing paragraphs are not offered as a review of the voluminous literature on peritonitis, but only to illustrate the variety of approaches which were suggested to us in getting at our principal primary objectives—a further understanding of the basis for the morbid sequences of peritonitis and of the possible role of chemotherapeutic agents in influencing the course of the disease

This initial paper deals with exploratory studies, during which various hypotheses concerning the morbid process were put to test in an attempt to find one or more factors which might correlate to a statistically significant degree with the mortality from the experimentally produced disease

MATERIALS AND METHODS

The animals used in this experiment were stray adult dogs obtained through regular channels They varied in weight from 5 to 15 kg, but averaged about 9 kg The animals were “debarked” under nembutal anesthesia on the day of arrival and then kept under observation until such time as they were to be used, but always for a period of at least two weeks The dogs were maintained in clean cages on a diet of “Munchy” dog meal,* supplemented with fresh meat twice weekly whenever such was available The original fifteen dogs were animals which had been in our colony for one year or more and on which other experimental procedures had been carried out, none of them involving laparotomy or injury to the peritoneum

Technique of Production of Peritonitis—Intravenous nembutal anesthesia, 300 mg per kilogram in 5 per cent solution, was used The abdomen was opened through a right lateral rectus incision and the appendix identified The mesoappendix was dissected free and the vessels ligated with silk An obstetrical tape tie was then applied tightly about the base of the appendix, care being taken not to break the continuity of the bowel A culture was obtained from the cecum by aspirating some feces through a 16 gauge needle into a syringe The needle hole was closed with a silk purse-string suture The abdominal wall was closed in three layers, using a continuous silk suture on the peritoneum and interrupted silk sutures on fascia and skin A collodion dressing was applied to the operative wound

*Manufactured by Parke and Pollard Boston Mass

Postoperative Treatment—Immediately postoperatively 500 c c of castor oil were placed in the animal's stomach through a stomach tube, after the technique of Fauley and associates. Bower had suggested that this procedure increased the mortality rate in experimental peritonitis.

Postoperatively most of the animals were given 200 c c per kilogram of 25 per cent glucose and 0.5 per cent normal saline solution intravenously every twelve hours. A small group of animals was given water by mouth ad libitum and another small group was given 200 c c per kilogram of water by mouth every twelve hours.

Animals subjected to this experimental procedure had a rather typical postoperative clinical course. Each animal's condition was observed at twelve-hour intervals postoperatively, and at these time intervals blood was drawn for the physical and biochemical determinations. On the basis of "clinical" observations the following stages in the disease were noted and named: Stage I, The Preoperative Phase, Stage II, the Postoperative Crisis, Stage III, Recovery from Postoperative Crisis, Stage IV, the Crisis of Peritonitis, and, if the animal survived, Stage V, Recovery. Stages II, III, and IV varied in duration between animals.

The Postoperative Crisis was characterized by a rise in temperature and respiratory rate, the animal being prostrate in the cage. The respirations were deep and full and cyanosis was never seen during this period. This was the typical condition of the dog at the twelve-hour postoperative period.

By twenty-four hours, the animals seemed usually to have recovered from the immediate effects of the operation and would, as a rule, respond to attention by standing up. The temperature readings varied slightly, but in the majority of cases temperatures of normal or near normal levels were recorded. The respirations invariably returned to normal during this stage, the Recovery From the Postoperative Crisis.

This period of relative improvement lasted twelve to forty-eight hours. Following this the clinical condition of the animal changed markedly with the onset of the Crisis of Peritonitis. The temperature and respirations rose, abdominal rigidity was noted, and the animal again was unable to rise. The respirations at this time were often very shallow, cyanosis was frequently seen, and the peripheral veins were dilated and dark in color so that they stood out clearly against the background of surrounding shaved skin. Stage IV lasted for from twelve to forty-eight hours.

Recovering animals (Stage V) showed a return of all factors to normal, and this recovery usually occurred rather abruptly, within a twelve-hour period, so that recovery seemed to be by crisis rather than by lysis, although many of the animals remained in weakened condition for a few days.

Autopsies—In a few preliminary experiments animals were sacrificed on the second, third, and fourth days in order to ascertain the course of local changes. By the second day the appendix had become a necrotic sack which had usually not ruptured, but evidence of generalized peritoneal infection could be discerned. By the third day there existed a diffuse peritonitis with

a completely gangrenous ruptured appendix. It seemed probable that rupture of the necrotic fluid-filled sac sometimes occurred rather suddenly, flooding the peritoneal cavity with as much as 1000 cc of fluid, containing many bacteria and their toxins and products of tissue and bacterial decomposition. The further sequences might be influenced to some degree by whether this leakage was abrupt or gradual. On the fourth day the omentum had begun to envelop the area of maximal necrosis, although abdominal exudate remained thick and malodorous.

Animals which died were autopsied within six hours, all other animals were autopsied on the tenth postoperative day. By this time a localized abscess of varying size was always present, acute inflammation of other peritoneal surfaces had subsided, but considerable amounts of clear or slightly turbid fluid were occasionally found. Cultures of the abdomen always yielded a variety of intestinal organisms. Autopsies done on animals dying during the first seventy-two hours confirmed the preliminary findings, except that the tendency for localization of the abscess was rarely seen, the bowel showed many serosal hemorrhages, and the abdominal exudate was grossly hemorrhagic.

In addition, extensive lesions of the lungs were regularly noted on gross examination. (The trachea was ligated before the thorax was opened.) There frequently existed a frank pneumonia, but in many cases the picture was indicative of atelectasis with vascular engorgement and parenchymal hemorrhage. Microscopic studies confirmed these findings and also revealed that the vascular engorgement was by no means confined to the lungs. Sections of liver, kidney, spleen, and adrenal showed dilated vessels and capillaries filled with red blood cells with occasional hemorrhages into the parenchyma of each of these organs.

Experimental Methods—

Collection of blood. Blood was taken under sterile precautions from the jugular veins of the animals every twelve hours, beginning preoperatively, and until the seventy-second postoperative hour. For biochemical studies, the blood was taken under oil and without an anticoagulant. The clotted specimen was centrifuged and the serum removed for study.

Blood for physical studies was taken in a dry syringe and immediately placed in small bottles containing 0.006 Gm of ammonium oxalate and 0.004 Gm. of potassium oxalate per 5.0 cc of blood.

Laboratory Methods.—Nonprotein nitrogen was determined by the micro Kjeldahl technique. Protein determinations were done after the method of Barbour and Hamilton as modified by Weech, Reeves, and Goettsch¹³ and, in some cases, by the copper sulfate method of Phillips and Van Slyke¹⁴. Chloride determinations were done by the Volland titration. Sodium and potassium determinations were carried out on the flame photometer*. Calcium levels were measured by the technique of Collip and Clark. Oxyhemoglobin was measured with the Evelyn photocolormeter.

*These determinations were done with the cooperation of the biochemistry laboratory of the Department of Internal Medicine.

Whole blood specific gravity and plasma specific gravity were estimated by the falling drop method, using copper sulfate solutions of varying specific gravity¹⁴

Erythrocyte sedimentation rate Erythrocyte sedimentation rate was measured in a Wintrobe tube and the amount of sedimentation occurring in thirty minutes was read as the end point

Hematocrit The level of packed red blood cells in the Wintrobe tube was determined after centrifuging at about 3,000 r p m until no further change occurred

Prothrombin times Both whole blood prothrombin times after the method of Abbott (using Abbott's thromboplastin)¹⁵ and plasma prothrombin times by the method of Quick¹⁶ were used Since the tests gave comparable readings in relation to their respective controls over a long series of experiments, the two tests are not differentiated in the discussions of prothrombin times in this paper

Red blood cell fragility determinations Red blood cell fragility determinations were done by the quantitative photoelectric method, described by Hunter¹⁷

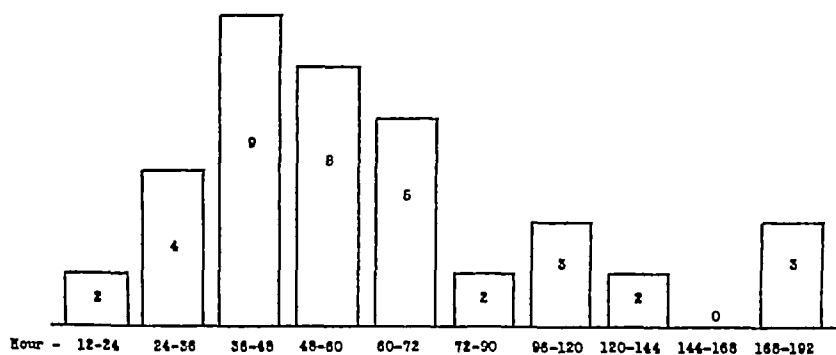


Fig 1—Distribution in mortality in experimental peritonitis, incidence of deaths at stated postoperative hours

EXPERIMENTAL RESULTS

Peritonitis was produced in ninety-one control animals, of these, fifty-three survived and thirty-eight died, a mortality of 41.7 per cent. The time of death varied from 12 to 192 hours postoperatively, the majority of deaths occurring at between twenty-four and seventy-two hours (Fig 1)

In order to determine the possible effect of allowing the animals to have fluid ad libitum, a group of twenty-four animals were subjected to the experimental procedure and no attempt made to restrict fluids postoperatively, water being offered freely. Of this group twelve animals had been in the colony for one year or more and twelve animals were of the group obtained specifically for this experiment and referred to as "new colony" dogs.

In Table I are shown the mortality statistics in this group, compared with the remainder of the control dogs who received only 200 cc of fluid per kilogram every twelve hours. Although at first glance it may seem that the method of fluid administration is accountable for the difference, a closer analy-

TABLE I

DOGS	WATER AD LIBITUM		SALINE GLUCOSE	
			(40 CC PER KILOGRAM PET DAY)	
	LIVED	DIED	LIVED	DIED
"Old" colony	11	1	3	0
"New" colony	7	5	32	32
Total	18	6	35	32

sis reveals that the figures are significant only in respect to the previous history of the animal in the colony

These results suggest that the dogs which were in the colony for a long time were more resistant to this experimental disease. The reason for this was not immediately apparent, although diet and previous experimental procedures were considered, as well as a possible measure of acclimatization against pulmonary infection in the "old" colony dogs.

A number of biochemical studies were carried out in somewhat random fashion in an attempt to determine what measurements might correlate sufficiently well with death or survival to justify their systematic use in subsequent studies.

Nonprotein nitrogen levels were followed throughout the course of the disease in fifteen animals. Of these, nine lived and six died. In the surviving group the highest reading was 75.0 mg per 100 c.c. the lowest 26.0, and the mean 36.0. In the dying group the highest value was 71.0 mg per 100 c.c., the lowest 23.0 and the mean 46.0.

Total protein concentrations showed a fall on the third postoperative day in the surviving animals, coincident with hemodilution. During the acute stage of the disease, however, there was no significant difference between the values in the surviving and dying animals. Falling-drop protein tests (Barbour and Hamilton) were done on fifteen dogs while plasma specific gravities and protein calculations by the copper sulfate method were done on the remaining seventy-six. The range of protein values during the crisis of peritonitis was, in the surviving animals (in grams per 100 c.c.), high 7.7, low 5.0, and mean 5.4, in the dying animals, high 7.5, low 5.0, and mean 5.55. There was no correlation between the preoperative values (which ranged from 4.8 to 6.9 Gm per cent of protein) and the subsequent course of the disease.

Chloride determinations were done on animals which received intravenous fluids as well as on those which took fluids by mouth. Although the chlorides were maintained at a higher level in the first group, there was again no correlation between the chloride level and the outcome of the final crisis.

Sodium and potassium levels were followed on only four animals, two of which lived and two of which died. Slight variations occurred during the course of the disease but there was no significant difference between the two pairs. In the two animals that died the last determination made shortly before death showed sodium levels of 141 and 139 m eq/L and potassium levels of 4.7 and 3.9 m eq/L. The surviving animals showed during the crisis of peritonitis

sodium levels of 137.0 and 139.0 meq per liter and potassium levels of 4.7 and 3.5 meq per liter.

The results of bacteriologic examinations are shown in Table II. There is no correlation between the types of organisms involved and the mortality. It is true that pathogenic organisms were found with greater frequency in cultures from the abscess and peritoneal exudate than in fecal cultures taken at the time of operation, but the pathogens occurred with almost equal frequency in the exudates of animals which survived and of those which succumbed.

TABLE II

TYPE OF ORGANISM	LIVED (TOTAL, 53)		DIED (TOTAL, 38)	
	CECUM CONTENTS	EXUDATE	CECUM CONTENTS	EXUDATE
<i>Esch. coli</i>	47	42	33	34
<i>Enterococci</i>	50	30	33	21
<i>B. welchii</i>	40	37	31	25
<i>Str. viridans</i>	44	37	31	23
<i>B. proteus</i>	16	12	1	16
Beta hemolytic streptococcus	1	23	1	8
Nonhemolytic streptococcus	19	12	10	8
<i>Bacteroides</i>	13	12	6	3
<i>Staph. albus</i>	2	12	1	7
Unidentified gram negative bacilli	0	2	0	4
<i>Bacillus A</i>	1	5	1	3
<i>Lactobacillus acidophilus</i>	7	1	3	1
<i>Diphtheroids</i>	6	9	7	5
<i>B. alcaligenes</i>	4	3	1	0
Anaerobic streptococcus	3	1	1	1
Unidentified anaerobic gram positive bacilli	7	11	1	5
<i>B. subtilis</i>	4	3	2	1
<i>B. mucosus capsulatus</i>	2	3	1	0
Hemolytic <i>Staph. aureus</i>	2	3	0	0
<i>Staph. citreus</i>	1	0	0	1
<i>Cl. septique</i>	1	0	0	1
<i>B. pyocyaneus</i>	0	1	0	1
<i>B. chauvoei</i>	0	1	0	0

The biochemical and bacteriologic observations which have so far been reviewed have failed to bring out characteristic differences between surviving and dying animals. However, certain consistent changes in some of the physical characteristics of blood were noted which seemed constantly to correlate with the stage of the disease. An effort has been made in Table III to show this correlation, with data from six representative animals.

Red blood counts, white blood counts, and hemoglobin showed no differences of significance in the dogs surviving and dying, although they followed a typical course, the white blood count rising early and falling slowly, if the animal survived. The red blood count and hemoglobin, after an occasional slight rise at the twelve-hour period, returned to normal for twelve to twenty-four hours and subsequently fell sometimes to strikingly low levels, if the animal survived. This fall in red blood count was frequently associated with serum jaundice, which in one case was clinically evidenced by jaundiced sclerae.

TABLE III CORRELATION BETWEEN THE COURSE OF EXPERIMENTAL PERITONITIS AND DEVIATIONS OF SELECTED BLOOD FACTORS

	STAGE I	STAGE II	STAGE III	STAGE IV	STAGE V
Rise in H Rise in WB Sp Gr Decrease in F time Prolonged PT time Decrease in ESR		147- II, WB, ESR, PT, F 150- II, WB, ESR, PT, F *158- II, WB, ESR, PT, F *162- II, WB, ESR, PT, F *164- II, WB, ESR, PT 180- II, WB, ESR, PT		147- I, WB, ESR, PT, F 150- I, WB, ESR, PT *158- I, WB, ESR, PT, F *162- I, WB, ESR, PT, F *164- I, WB, ESR, PT 180- I, WB, ESR, PT	
2+			147- H, WB *158- H, ESR, PT, F *162- ESR, PT *164- PT 180- ESR		
11			147- PT, F 150- PT, II		147- PT, F 150- PT
0	147 150 *158 *162 *164 180		180- WB 147- ESR 150- WB, ESR *158- WB *162- H, WB, F *164- H, WB, ESR, F 180- WB		180- PT 147- H, WB, ESR
1-		*164 (F)			
2-					150- H, WB, ESR 180- H, WB, ESR

*Animal Died
H Hematocrit
WB WB Sp Gr Whole blood specific gravity
ESR, Erythrocyte Sedimentation Rate
PT Prothrombin Time
F, Fibrinogen

In addition, during Stage IV, the Crisis of Peritonitis, hemolysis was frequently observed, and many of the animals showed a progressive curve of hemolysis, the blood taken every twelve hours showing increasing hemolysis up to the time of the crisis and then decreasing hemolysis and serum jaundice.

The thirty-minute erythrocyte sedimentation rate became markedly reduced during the postoperative crisis. It increased during Stage III, decreased again (frequently to zero) during Stage IV, and when recovery occurred, the rate would invariably be very rapid, frequently reaching 50 to 70 mm in thirty minutes.

Variations upward and downward in the whole blood specific gravity and the hematocrit tended to follow the same general pattern. A decrease of the thirty-minute erythrocyte sedimentation rate was accompanied by an increase of the whole blood specific gravity and of the hematocrit, and an increase in the thirty-minute erythrocyte sedimentation rate was accompanied by a fall in whole blood specific gravity and hematocrit.

These changes were most marked in the shift from Stage IV to Stage V, Recovery From the Crisis of Peritonitis. Thus, within a period of twelve hours the sedimentation rate might change from 0 to 40 mm or more, and the whole blood specific gravity might simultaneously fall from 1.060 to 1.050 or less, this change being unassociated with a comparable drop in red cell count or hemoglobin. Recovery From the Crisis of Peritonitis was marked by a fairly precipitate drop in whole blood specific gravity and hematocrit and a concurrent increase in the sedimentation rate. Animals which displayed these changes following a period of critical illness could be said to have passed the danger period.

Since hemolysis had been noted during the crisis of peritonitis, red blood cell fragility tests were made every twelve hours during the course of the disease on a group of seven animals. Changes in fragility appeared concurrently with the previously described changes in specific gravity, hematocrit, and erythrocyte sedimentation rate, the fragility increasing during the postoperative crisis and the crisis of peritonitis, and decreasing during both recovery periods.

Finally, it was observed that the blood taken during the crisis of peritonitis did not clot readily, and when it did clot, it was in the nature of a soft thrombus, and clot retraction did not occur. A preliminary series of whole blood prothrombin time determinations were done at the twenty-four, forty-eight, and seventy-two hour postoperative periods. It appeared that animals whose prothrombin times were consistently normal survived, whereas animals whose prothrombin times were prolonged as much as two or three seconds at the twenty-four and forty-eight hour periods tended to die. An occasional animal in the latter category survived, but remained in poor condition until the prothrombin time had returned to normal.

There appeared to be a relationship between prolongation of prothrombin time and the severity of respiratory distress. Therefore, x-ray examinations of the lungs were performed on a few sick animals. Roentgenograms were taken daily for four days, commencing preoperatively. The results indicated a

definite association between the onset of pulmonary disease and the development of prolongation in prothrombin time. Figs 2 and 3 show sets of roentgenograms on two representative animals. The first had a normal prothrombin time at the twenty-four, forty-eight, and seventy-two hour periods, and x-ray

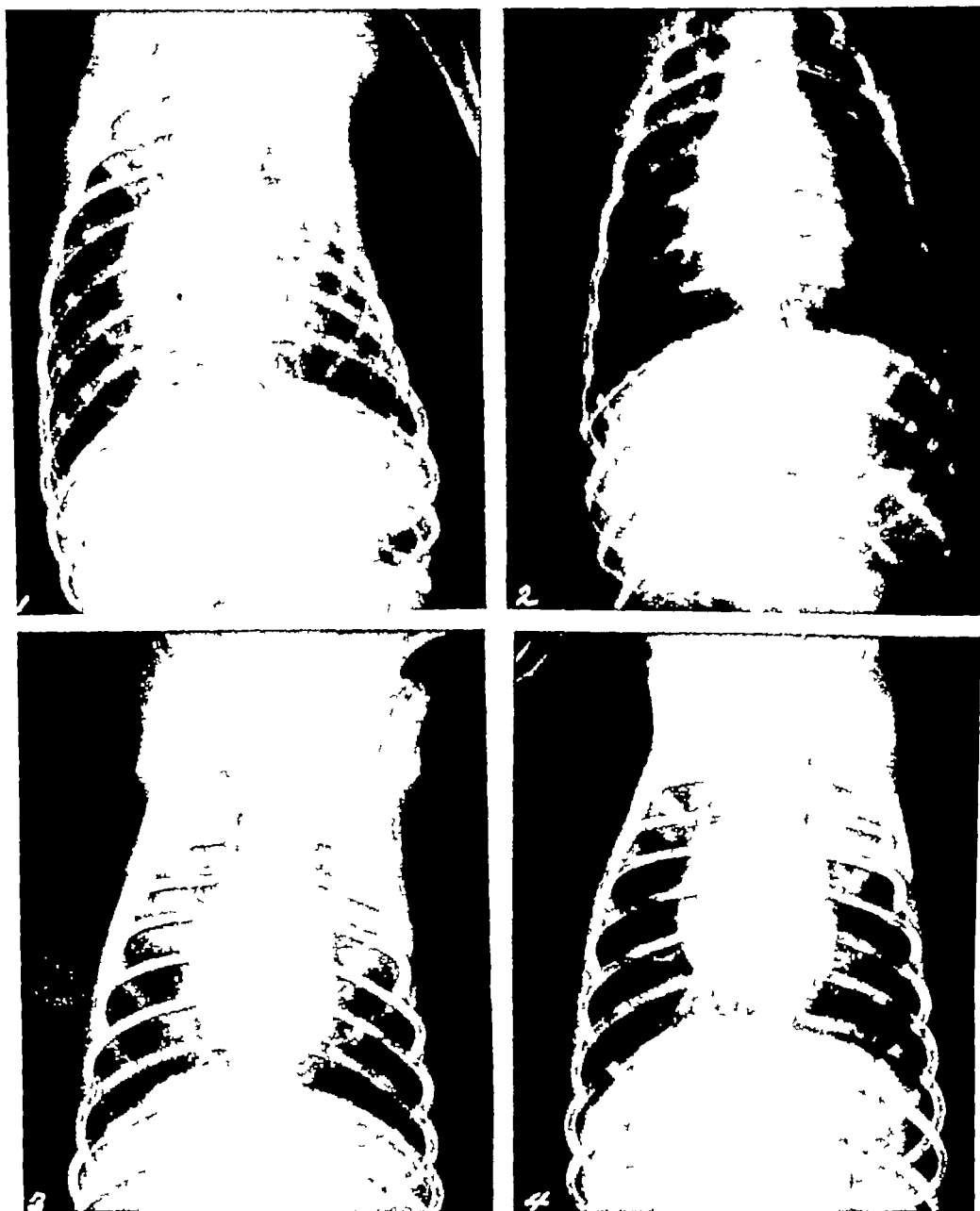


Fig 2 (Dog 147)—Roentgenograms of lungs during experimental peritonitis. Dog survived (1) Preoperative, (2) twenty-four hours postoperative, (3) forty-eight hours postoperative, (4) seventy-two hours postoperative. These roentgenograms show no significant changes in an animal whose prothrombin time remained normal and who survived.

views taken at the same period showed little abnormality. The second animal, however, showed a prothrombin time of 10/7 at twenty-four hours and of 12/7 at forty-eight hours, this animal died at about seventy hours and the last x-ray

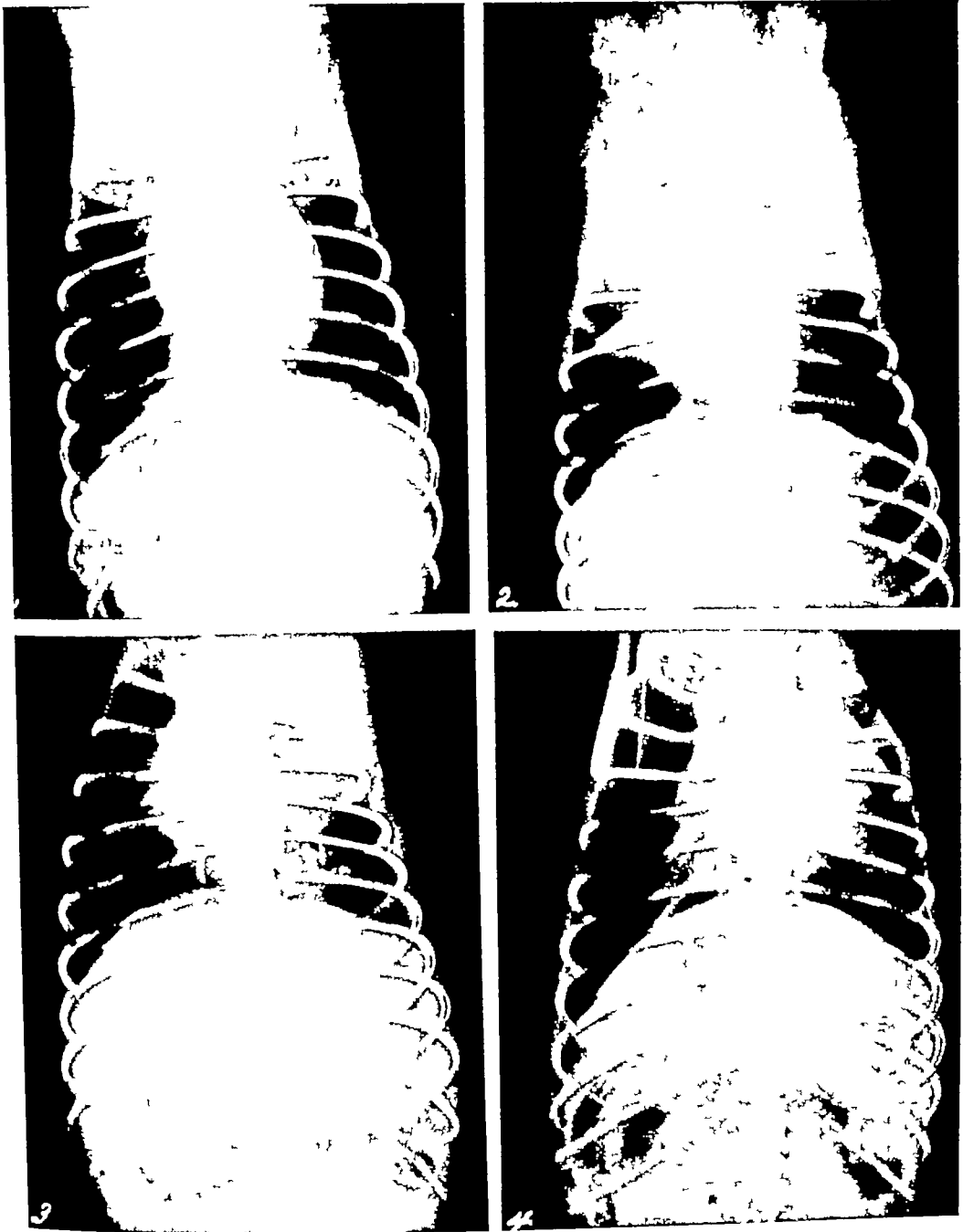


Fig 3 (Dog 148) —Roentgenograms of lungs during experimental peritonitis. Dog died (1) Preoperative (2) twenty-four hours postoperative, note atelectasis of right middle lobe (3) forty-eight hours postoperative, note disappearance of atelectasis seen in previous view (4) seventy-two hours postoperative (two hours post mortem) note complete atelectasis of right lower lobe. This animal had prolonged prothrombin time throughout the course.

view was taken two hours post mortem. The twenty-four hour roentgenogram showed a type of consolidation consistent with atelectasis, an impression supported by its complete disappearance at forty-eight hours. The post-mortem roentgenogram, before autopsy, showed collapse of the lung and bilateral pneumothorax. Autopsy revealed an early pneumonia in the left upper lobe with bilateral hydropneumothorax, the fluid being frankly bloody in character and showing intestinal organisms on culture.

Because of the apparent significance of the prothrombin time, such estimations were done every twelve hours on all of the animals subsequently studied (Table IV). The changes in prothrombin time correlated with other changes in physical properties of the blood, in that the prothrombin time was consistently prolonged in Stage IV, and returned to normal in Stage V if the animal survived. In general, as had been noted when prothrombin times were done only every twenty-four hours, if the prothrombin time returned to normal in Stage III, the animal tended to survive. If the prothrombin time did not return to normal in Stage III, the animals either died or survived only after severe illness. The prognostic significance of the prothrombin time reading at Stage III is shown in Table V. It should be noted that animals at this stage gave little outward appearance of being acutely ill, the severe reaction to peritoneal infection having not yet commenced.

In view of the possibility that prolonged prothrombin time might be due to increase in circulating heparin, protamine titrations were done on several specimens from each stage, using the technique described by Tagnon¹⁸.

TABLE IV WHOLE BLOOD PROTHROMBIN TIMES*
EXPRESSED AS $\frac{\text{PROTHROMBIN TIME OF EXPERIMENTAL ANIMAL}}{\text{PROTHROMBIN TIME OF CONTROL (NORMAL) ANIMAL}}$

DOG NO.	STAGE OF DISEASE				
	I	II	III	IV	V
99	7/7		7/7		7/7
92 ^a	7/7		7/7		7/7
119	7/7		13/7	10/7	Died
116	7/7		16/7	Died	
123	7/7		10/7	10/7	Died
141	7/7		7/7	7/7	7/7
137	7/7	14/7		10/7	7/7
138	7/7		7/7	7/7	7/7
144	7/7		12/7	Died	
145	7/7		9/	14/7	7/7†
147	7/7	9/7	7/7	15/7	7/7
148	7/7	10/7	9/7	12/7	Died
149	7/7	7/7	7/7	13/7	7/7
150	7/7	7/7	7/7	10/7	7/7
152	7/7	8/7	8/7	Died	
154	7/7	7/7		9/7	7/7
156	7/7	11/7	14/10	15/7	8/7†
158	7/7	9/7	12/7	13/7	Died
160	10/10	17/7	24/7	38/7	Died
162	8/8	11/8	9/7	12/7	Died
164	5/5	7/5	9/5	10/5	Died
166	7/7	9/7	8/8	8/6	7/7

*Parallel determinations of plasma prothrombin time (Quick) were so similar that these figures have been omitted.

†Survived after extremely stormy course.

TABLE V PROGNOSTIC SIGNIFICANCE OF PROTHROMBIN TIME BEFORE CRISIS OF PERITONITIS

AT STAGE III	LIVED	DIED	PER CENT MORTALITY
Normal prothrombin time	9	1	10.0
Prolonged prothrombin time	2	10	83.3
Total	11	11	50.0

In no case was the prothrombin time returned to normal by addition of protamine, so it seemed unlikely that heparin was responsible. A sample titration is shown in Table VI.

TABLE VI PROTAMINE TITRATION (DOG 195)

PROTAMINE CONCENTRATIONS (PER CENT)	PROTHROMBIN TIME (SECONDS)
0.02	30
0.018	28
0.016	24
0.014	19
0.012	19
0.010	19
0.008	19
0.004	19
0.002	19
0.001	19
Control	12

The prolongation in prothrombin time appears to be related to the failure of the clotting mechanism in the blood of animals dying of peritonitis, and to the occurrence of hemorrhagic changes in the peritoneum, liver, and lungs of many of these animals. One obvious explanation of the disturbed clotting mechanism is the development of severe injury to the liver parenchyma from anoxia or bacterial toxins. There seems little doubt but that therapeutic measures capable of giving support to liver function would favor survival if initiated before severe hepatic injury occurs. However, before pursuing this approach to the treatment of peritonitis, it was decided to undertake further investigation of the blood, in order to determine whether all of the morbid hematologic findings described might be traced to a common mechanism. Subsequent studies, which suggest that this mechanism may be a disturbance in the equilibrium between circulating proteolytic and antiproteolytic factors, will be reported in a later paper.

DISCUSSION

Peritonitis resulting from induced gangrene of the dog's appendix is an extremely complex disorder, involving marked disturbances in hemodynamics, significant shifts in water, protein, and electrolyte balance, and functional disturbances of the gastrointestinal tract, the liver, kidney, lungs, and possibly the spleen, adrenals, and hematopoietic system. Any attempt at a determination of what may be the underlying pattern of the morbid sequences is likely to be thwarted by the same obstacles which beset the student of "surgical shock" in any of its forms where differentiation between cause and effect is necessarily difficult. In the study here reported, advantage has been taken of the fact

that about one-half of randomly selected dogs will die when subjected to a uniform experimental procedure and given minimal supportive treatment with water, sodium chloride, and glucose, while the remainder will survive following a stormy illness. Our search has been directed not so much toward characterization of the disease process as a whole as toward detection of what specific differences might exist between the reaction to the disease in surviving animals, as contrasted with animals which died. It is apparent that purely accidental factors beyond experimental control, such as time of perforation of the necrotic appendix, and the effectiveness of omental isolation of the lesion, may play a decisive role in the outcome, although the pathologic findings do not lend support to this interpretation. Of more plausible significance is the role of unknown variables in the previous history and condition of the animals, variables which must always be anticipated among a heterogeneous group of stray dogs. However, it is to no small extent the variable factors in just this poorly defined realm which determine the mortality of peritonitis in man, given similar conditions of surgical management. Differences in bacterial flora may be of some significance, but as in these dogs, the flora of dying and of surviving patients are not qualitatively dissimilar. Fortunately, from the standpoint of the investigator, the disease in dogs builds up to a fairly clear-cut crisis, and upon the reaction to this crisis depends the outcome of the disease. Of all the factors which we have measured, those which have most clearly displayed their lability or reversibility during the crisis of the disease are the whole blood specific gravity, the hematocrit, the erythrocyte sedimentation rate, and the blood-clotting reactions.

Of the greatest specificity has seemed to be the time required for clotting of blood or plasma upon the addition of thromboplastin, the prothrombin time. Animals which best maintained the normality of this reaction throughout the postoperative period were those which tended to survive the crisis of the disease, and those which did not, died.

Therefore, in moving toward a better understanding of the nature of resistance to peritonitis, it would seem desirable to apply to this disease a thorough experimental investigation of fibrinogen, prothrombin, and calcium, and the enzymes and antienzymes, which, taken together, determine the rate, quality, and magnitude of the blood-clotting mechanism.

SUMMARY AND CONCLUSIONS

1 The gross and microscopic autopsy findings in ninety-one animals with induced peritonitis indicate that peritonitis is a systemic disease.

2 The trend toward death or survival in the individual animal cannot be correlated with quantitative changes in nonprotein nitrogen, plasma electrolytes, or total plasma proteins.

3 Systematic study of certain physical properties of blood, notably the hematocrit, erythrocyte sedimentation rate, whole blood specific gravity, and red blood cell fragility, indicates that the disease may be separated roughly into four stages, and that these properties tend to shift simultaneously in the movement of the disease from one stage to another.

4 Changes in prothrombin time not only reflect the various stages of the disease, but also seem to be of prognostic value even before the onset of the disease crisis

5 Understanding of the morbid processes in peritonitis will be advanced if the basis for abnormalities in the blood clotting mechanism in dying animals can be discerned

The authors wish to acknowledge the valuable technical assistance of Miss Betty Lewit, Miss Charlotte Welch and Mr Louis Capiello

REFERENCES

- 1 Fauley, G B, Duggan, T L, Stormont, R T, and Pfeiffer, C C The Use of Penicillin in the Treatment of Peritonitis, *J A M A* 126 1132, 1944
- 2 Rhoads, I E Unpublished data supplied in personal communication
- 3 Boor, A K, and Miller, C P The Effect of Penicillin on the Lethal Action of meningococcal endotoxin in Experimental Animals, *Science* 102 427, 1945
- 4 Bower, J O, Burns, J C, and Mengle, H A Induced Spreading Peritonitis Complicating Acute Perforative Appendicitis, *Surg, Gynec, & Obst* 66 947, 1938
- 5 Bower, J O, Burns, J C, and Mengle, H A The Bacteriology of Spreading Peritonitis Complicating Acute Perforative Appendicitis, *A Clinical and Experimental Study, SURGERY* 3 645, 1938
- 6 Bower, J O, Mengle, H A, and Paxson, N F The Demonstration of Antitoxin for Toxin of *Clostridium Welchii* in the Blood Serum of Patients and Dogs That Have Recovered From Spreading Peritonitis Complicating Acute Perforative Appendicitis, *J Immunol* 34 185, 1938
- 7 Meleney, F L, Harvey, H D, and Jern, H Z Peritonitis, Correlation of Bacteriology of Peritoneal Exudate and Clinical Course of Disease in 106 Cases of Peritonitis, *Arch Surg* 22 1, 1931
- 8 Elman, Robert Recent advances in Surgery, Particularly From the Standpoint of Improving Prognosis With Special Reference to the Correction of Protein Deficiencies, *Connecticut M J* 6 913, 1912
- 9 Scudder, J, Drew, C R, and Sloan, L W Anhydremia in Appendicitis, *S Clin North America* 19 295, 1939
- 10 Scudder, John Shock Blood Studies As A Guide To Therapy, Philadelphia, 1940, J P Lippincott Co
- 11 Altmeier, W A, and Jones, H C Experimental Peritonitis Its Prevention by Roentgen Irradiation, *J A M A* 114 27, 1940
- 12 Bisgard, J D, Hunt, H B, Neely, O A, and Scott, P Symposium on Abdominal Surgery Mechanism of Action of Roentgenotherapy Upon Infection, *Ann Surg* 115 996, 1942
- 13 Weech, A A, Reeves, E B, and Goettsch, E The Relationship Between Specific Gravity and Protein Content in Plasma, Serum, and Transudate From Dogs, *J Biol Chem* 113 167, 1936
- 14 Phillips, R A, Van Slyke, D D, Dole, V P, Emerson, K, Jr, Hamilton, P B, and Archibald, R M Copper Sulfate Method for Measuring Specific Gravities of Whole Blood and Plasma, *Bull U S Army M Dept* 71 66, 1944
- 15 Ziffren, S E, Owen, C A, Hoffman, G R, and Smith, H P A Simple Bedside Test for Control of Vitamin K Therapy, *Am J Clin Path, Tech Supp* 4 13, 1940
- 16 Quick, Armand J The Nature of the Bleeding in Jaundice, *J A M A* 110 1658, 1938
- 17 Hunter, F T A Photoelectric Method for Quantitative Determination of Erythrocyte Fragility, *J Clin Investigation* 19 691, 1940
- 18 Tagnon, H J Nature of Mechanism of Shock Produced by Injection of Trypsin and Thrombin, *J Clin Investigation* 24 1, 1945

NEOPLASTIC BILIARY OBSTRUCTION

AN IMPROVED TYPE OF RADICAL PANCREATODUODENECTOMY FOR AMPULLARY AND PANCREATIC CANCERS

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NEOPLASTIC biliary obstruction was generally a hopeless ailment until the introduction of a successful radical operation by Whipple and his associates¹ in 1935. When those workers showed that the pancreatic duct could be occluded without fatal results in resections of the ampulla of Vater, interest was at once aroused in an attack not only on carcinoma of the ampulla but on cancer of the head of the pancreas as well. The impulse of this discovery was perhaps fortuitous in that later experimental work has shown the advisability of reanastomosis of the pancreatic ducts to the intestine.²

Diagnosis—This presentation is not primarily concerned with diagnostic considerations. About one-third of those cases summarized in this report have histories not of classical painless progressive jaundice, but of jaundice preceded or accompanied by bouts of "biliary pain." The diagnostic studies of Watson³ and his associates have offered an almost perfect record in this group of cases.

The Development of Radical Pancreatic Duodenectomy—Prior to 1941, Whipple's original plan of performing pancreaticoduodenectomy in two stages was generally followed. The first was primarily for creation of a new passage by which bile could enter the intestine and thus control the abnormal bleeding tendency associated with biliary obstruction. Usually a gastrojejunostomy was done at this first sitting also to facilitate both preoperative feeding and the performance of the resection of the tumor at a second stage some weeks later.

With the introduction of vitamin K, it became possible to control this bleeding tendency without relief of the biliary obstruction, and, in 1941, Whipple⁴ and Trimble and associates⁵ independently reported a one-stage operation for the removal of cancers of the head of the pancreas or ampulla of Vater. Aside from the lessened risk of one operation as opposed to two, freedom from the adhesions of a prior stage made complete block resection of these lesions more frequently possible.

Although Whipple and Bauman⁶ have shown that patients usually have good fat digestion after exclusion of pancreatic juice from the intestine, some of their patients suffered steatorrhea. Diagstedt² noted in animals that a much better nutritive state exists after partial pancreatic resection when a remnant of the pancreas with a duct is left on the duodenum, and suggested implantation of the pancreatic duct into the stomach or intestine as a part of the Whipple pro-

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cedure Hunt⁷ attempted to anastomose the pancreas into the cut end of the severed jejunum in 1941, and a variety of plans for achieving this result have been described by other workers during the past four years.

In line with these findings the now generally accepted repairs after radical resection of cancer of the head of the pancreas include not only reconstruction of a biliary-intestinal fistula and a gastroenterostomy, but also a pancreaticoenterostomy. The exact types of procedure employed by various authors are of considerable interest, and the most important ones will be briefly sketched later.

Considerations in the Radical Resection —

Biliary anastomosis Upon review of the pertinent literature, several considerations become apparent with regard to the performance of a satisfactory operation. The first of these is the prevention of ascending cholangitis following anastomosis between the biliary and intestinal tracts, a complication of considerable frequency in the best of hands. Trautmann, Robbins, and Stewart⁸ showed in experimental studies in dogs that simple side-to-side anastomosis of bowel to gall bladder uniformly is followed by passage of intestinal content into the biliary tract. Cole and Reynolds⁹ reported the development of suppurative cholangitis in two patients with radical pancreaticoduodenectomy in whom the biliary anastomosis was made distal to the gastric anastomosis. In both, "the chills and fever stopped abruptly when we interrupted the loop of jejunum which had allowed reflux of food into the intrahepatic ducts." We have adopted the plan here of placing the gastric anastomosis well below the biliary one.

Wangensteen¹⁰ made a rather exhaustive study into the literature in connection with the reporting of a case of ascending cholangitis after cholecyst-jejunostomy, his review of all studies on the subject up to 1928 indicates that the avoidance of stenosis at the site of anastomosis is at least as important as the prevention of reflux from the intestine into the biliary tract.

Pancreatic anastomosis Another consideration of some importance in the radical resection of the duodenum and the head of the pancreas is that of the handling of the pancreatic duct. In Whipple's first cases and in those of most other authors until 1942, including that previously reported from the University of Minnesota, the pancreatic duct was simply ligated and the cut end of the gland carefully closed with fine silk. The end result of this was usually degeneration of the acinar portion of the remaining pancreas.^{2, 6, 11} The experimental work of Whipple and Bauman^{4, 6} indicated that most of these patients suffered no serious interference with fat metabolism, this was perhaps due to the leaving of portions of the duodenum containing small accessory pancreatic ducts. In the case reported from here¹² and equivocally in some of those of Brunschwig,¹³ instances of steatorrhea were observed, with impaired nutrition. Dragstedt² has shown that complete blockage of the pancreatic juice from the intestine of the dog results not only in degeneration of the acini, but interferes with the internal secretion, lipocaine, in one-half the animals, leading to the formation of fatty changes in the livers of these subjects. These findings have led most surgeons to attempt to reanastomose the pancreatic and intestinal lumina in the radical operations.

Simplicity of procedure A further consideration is the development of the simplest procedure possible, one with a minimum of anastomoses, etc., a factor demanded by the usual poor condition of these patients

Preoperative preparation The preoperative preparation of the poor-risk patients must follow the lines that have already been stressed in publications from the department^{14, 15}

Representative Procedures —

Cancer of the head of the pancreas or of the ampulla with extension into the duodenum, common duct, or pancreas The original operation of Whipple, Parsons, and Mullen¹ was done in two stages, the first of which was composed of cholecystogastrostomy and gastroenterostomy, and the second of which was resection of the head of the pancreas and much of the duodenum, with inversion of all cut ends (see Fig. 1)

A second type is Whipple's procedure of 1938,¹⁶ in which a wider resection and a Roux Y-plasty permitted him to use the cut end of the jejunum to make an end-to-end anastomosis to the gall bladder

Hunt⁷ (1941) first attempted to anastomose the pancreas to the jejunum in this type of case. An end-to-end pancreaticojejunostomy was made, and the common bile duct was implanted into the side of the bowel. The patient suffered from pancreatic fistulas. Implantation of the common bile duct instead of the gall bladder was adopted by Hunt and others because it had been found that the closed end of the duct was prone to blow out, no matter how carefully closed.

The operation of Trimble, Parsons, and Sherman⁵ (1941) introduced the use of the cut end of the stomach directly for the gastrojejunostomy, rather than the more clumsy closure of the end of the stomach and side-to-side gastroenterostomy, as previously.

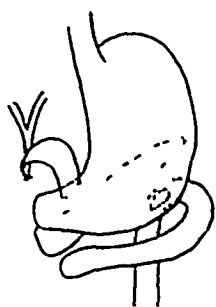
The operation of Dennis¹² (1942) stressed for the first time the use of a long jejunal loop (40 cm) between the end-to-end biliary anastomosis and the gastrojejunostomy as a means of preventing reflux of intestinal content into the biliary tract. Gastrointestinal studies on these patients failed at any time to show reflux for more than a fraction of the distance from the stomach to the gall bladder. Likelihood of ascending cholangitis was further reduced by use of the end-to-end cholecystojejunostomy, adopted because it was thought to minimize the likelihood of stenosis. This operation was designed to be as simple as possible, whereas all previous operations had involved a minimum of four suture lines, and several as many as six, thus required but three. Trouble was encountered with blowout of the common duct closure, a factor which has led us to employ the common duct directly for anastomosis to the jejunum.

Whipple's operation of 1943¹⁷ incorporates this general plan of simplification, but includes a pancreatic anastomosis. Because of the short loop between the common bile duct anastomosis and the gastric anastomosis, it seems to us that it fails adequately to insure against reflux from the stomach into the biliary tract.

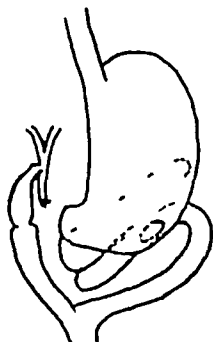
Numerous other procedures have been published, but they seem not to be crucial in the development of the ideal operation. An excellent summary of them is given by Oll²¹

The University of Minnesota operation The operation which we have now gradually developed as standard at this clinic has resulted from our own ex-

Whipple et al 1935



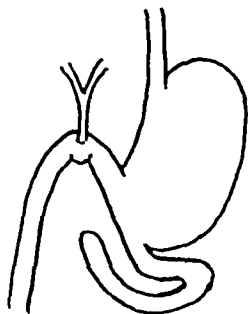
Whipple 1938



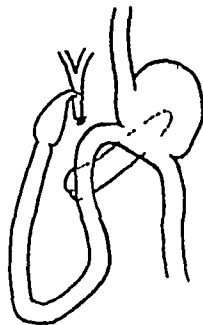
Hunt



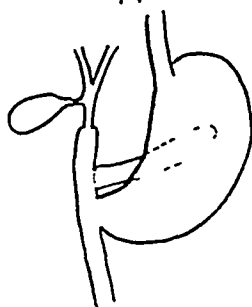
Trimble et al



Dennis 1942



Whipple 1943



Dennis and Varco

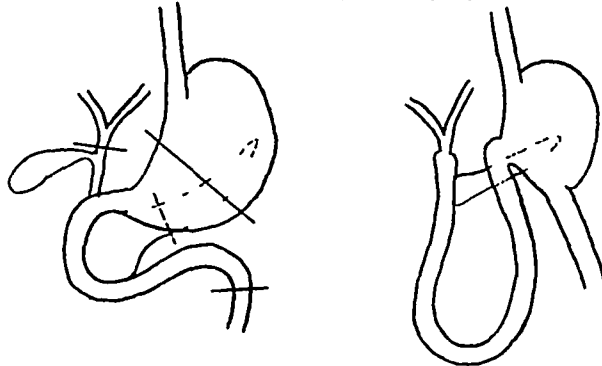


Fig 1

periences as much as from perusal of ideas expressed in the literature. A radical resection is performed, with removal of the distal third of the stomach, all the duodenum, the first 15 cm of jejunum, about two-thirds of the common

bile duct, and the head, uncinate process, and neck of the pancreas in one block of tissue. The cut end of the remaining jejunum is temporarily closed and brought through the right side of the transverse mesocolon. The gall bladder is removed, and the cut end of either the common hepatic duct or the common bile duct is used for end-to-end anastomosis to the jejunum. In performing this anastomosis we employ fine silk as the suture material. As the jejunum passes the cut end of the pancreas, an anastomosis of the pancreatic duct to this viscus is made. At a point 40 cm down the jejunum, a retrocolic Polya gastrojejunostomy is performed. Penrose drains are placed adjacent to the pancreatic and biliary anastomoses, and the abdomen is closed.

Anastomosis of the pancreas has been attempted by various maneuvers in the past. Coffey¹⁸ attempted it by rather complicated plastic procedures on the bowel prior to implantation of the entire head, or tail, or the organ. He found the difficulty to be that tissue juices activate the proteolytic enzymes of the pancreatic juice, with resultant digestion of the vulnerable suture line. Poth¹⁹ devised a silver button over which anastomosis could be made. Varco's method consisted in insertion of a catheter into the pancreatic duct, ligating it securely, and inserting it through a small stab wound into the intestine for 8 or 10 cm.²⁰ The anterior and posterior capsules of the pancreas are then sutured accurately to the serosa of the intestine about 1 cm from the catheter entrance into the bowel. Such a scheme assures healing by delivering the proteolytic juice into the intestine at a distance from the healing suture line.

The Cancer Institute at the University of Minnesota has recently acquired a contact therapy machine by means of which areas not susceptible to surgical excision may be rapidly irradiated through the open wound. Five thousand roentgens (air) with a penetration of less than 1 cm can be applied in 100 seconds. This has been employed in one case in this series and will probably be given further trial.

This final radical operation has been employed in six cases.

CASE REPORTS

CASE 1—A S, a 73 year old woman, entered the Minneapolis General Hospital with a history of progressive painless jaundice and cardiac failure, which proved to be on an arteriosclerotic basis. Watson tests showed carcinomatous biliary obstruction. Following digitalization and cholecystostomy her condition very slowly improved on our usual preoperative regimen.¹⁴ On Feb 18, 1945, exploration was done. A well localized lesion in the head of the pancreas was removed by the radical procedure described, but the gall bladder was left despite the presence of stones because it had been necessary repeatedly to await return of the pulse and blood pressure to normal levels, and gross transfusion had been feared because of the cardiac status. The postoperative course was surprisingly smooth, although she was slow to gain weight.

She returned to the Minneapolis General Hospital late in September with right upper quadrant pain in attacks. Passage of a gallstone into the common bile duct with impaction at the anastomosis was diagnosed and verified at operation, Oct 10, 1945. The abdomen was free of evidence of tumor. The gall bladder was removed and the stone pushed into the jejunum. The postoperative course was marred by some purulent drainage around a wick left in the operative site, but the incision healed nicely, and the patient remains well, afebrile, and free of jaundice.

CASE 2—T M, a 74 year old man, came to the University of Minnesota Hospitals on April 3, 1945, with jaundice of six months' duration, associated at the onset with pain. He had had three previous operations on the biliary tract, the last in 1940. Watson tests four months earlier had indicated hepatitis, but on this admission extrahepatic obstruction was indicated. Exploration on April 17, 1945, revealed a cancer of the common bile duct involving the duodenum. Radical resection was done. The patient died suddenly, in forty eight hours, of pulmonary embolism, proved at autopsy. (Note: This had been feared because of extreme preoperative lethargy. On another occasion the vena cava will be ligated.)

CASE 3—J S, a 66 year old man, came to the University of Minnesota Hospitals Aug 29, 1945, with a two month history of painless jaundice. Studies indicated carcinoma, nomatous obstruction, and radical resection was done Sept 13, 1945. The postoperative course was complicated by a biliary fistula which closed in a few days. He went home, feeling well, Oct 6, 1945.

CASE 4—M J, a 66 year old woman, came to the University of Minnesota Hospitals Oct 10, 1945, with a four month history of painless jaundice. Watson tests indicated a cancerous obstruction and at operation Oct 19, 1945, a radical resection was done for carcinoma, apparently of the intramural common duct. Drainage was omitted. The postoperative course has been uneventful to date (three and one half months).

CASE 5—M O, a 57 year old woman, came to the University of Minnesota Hospitals Nov 19, 1945, with a six month history of three bouts of jaundice and right upper quadrant pain and complete remission of all symptoms and jaundice between these episodes. Liver function studies were within normal values, a cholecystogram indicated a nonfunctioning gall bladder. At the time of exploratory surgery on Jan 24, 1946, a neoplastic process of the ampullary area was encountered, and a radical resection performed. Catheter drainage of the choledochojejunostomy anastomosis was carried out via the cystic duct. The postoperative course has been satisfactory to date (Feb 1, 1946).

CASE 6—H A, a 74 year old man, came to the University of Minnesota Hospitals on Dec 2, 1945, with a five week story of weight loss and increasing painless jaundice. The liver function tests were diagnostic of neoplastic biliary obstruction. On Dec 14, 1945, a radical resection for carcinoma of the ampullary area and head of the pancreas was carried out. Catheter drainage of the choledochojejunostomy anastomosis via the cystic duct was employed. The postoperative course was uneventful.

The difficulties inherent in such radical procedures are many, but the ones which have bothered most are

- 1 Exposure. We have come to use a long transverse incision plus a vertical upward extension from the center (Brunschwig incision). This is adequate and minimizes the need for retraction. All have healed primarily.

- 2 Establishment of operability. After exposure of the lesion, it is often impossible to determine whether it involves the wall of the portal vein or the superior mesenteric vein until the operator has been committed to resection by division of the pancreas or the stomach. Involvement of other vessels, as the hepatic artery or splenic vein, occurs only a little less frequently, but is less difficult to determine.

- 3 Dissection of the portal vein and superior mesenteric vein from the pancreas. These vessels are friable and are joined to the pancreas, which partially surrounds them, by numerous fine tributaries which bleed profusely if torn. Adoption of the coagulating current to control these vessels has facilitated this dissection enormously. Dissection is also rendered difficult by the frequency of neoplastic or inflammatory adhesion to the walls of these veins.

4 Vascular anomalies These are apparently frequent We have done one procedure in which the celiac axis was absent and the hepatic artery arose from the superior mesenteric artery and traversed the head of the pancreas, in another the portal vein crossed entirely in front of the neck of the pancreas

Other phases of the operation are straightforward, but time consuming

Carcinoma of the Ampulla of Vater—In 1899 Halsted reported a case of successful excision of a carcinoma of the ampulla of Vater by a transduodenal approach, utilizing local excision of the lesion and reimplantation of the ducts into the resulting defect in the mucosa of the posterior duodenal wall²¹ To date, this procedure has not been superseded The single difficulty lies in failure to remove a wide block of tissue surrounding the lesion A further practical difficulty sometimes has arisen here, namely, that more than the mucosa of the posterior duodenal wall may have to be removed, leaving a defect which is difficult to close

Palliative Procedures—Our experience has confirmed the impression that life can be prolonged and made more comfortable in the patients with frankly inoperable lesions Following consistent failure in our hands of the stoma to remain patent after anastomosis of the gall bladder to the stomach or duodenum, we have come to employ routinely an end-to-end cholecystojejunostomy, or an end-to-end choledchojejunostomy with a modified Roux Y-plasty of the intestine None of these has closed or leaked, and there has been no case of cholangitis

Several of these patients have already developed duodenal obstruction at the time of the palliative operation, and some of them have developed obstruction after successful cholecystenterostomy We are therefore inclined to favor gastrojejunostomy in addition to the biliary anastomosis as a part of the palliative procedure

Through the use of these combined procedures rather than the more commonly employed simpler procedures, we feel that longer and better palliation has been obtained, and the operative risk seems to be no higher than for exploration alone

SUMMARY OF CASES

In the period from Jan 1, 1937, to Feb 1, 1946, we have been able to find forty-six patients with biliary tract obstruction due to cancer who have passed through the main operating room at the University of Minnesota Hospitals and the Minneapolis General Hospital Several other patients who arrived in terminal condition, or were not subjected to surgery for other reasons, are not included The mortality rate of exploration in the twenty-three lesions found to be nonresectable has been higher than one might have expected One-third of the nine patients having exploration alone failed to survive surgery Twenty-one per cent of the fourteen given some sort of palliative procedure also died

Those patients subjected to local excision of carcinomas of the common bile ducts or ampulla of Vater constitute the most gratifying group There were nine altogether, with only one surgical death, the patient dying of hepatorenal syndrome

Among the fourteen patients subjected to radical pancreaticoduodenectomy there were four deaths. One man, who had had an extensive carcinoma of the common bile duct removed, died of pulmonary embolus two days later. He had been very lethargic for many days before surgery, and embolus had been feared. We feel now that the vena cava should have been ligated at the time of resection. In another patient the hepatic artery arose from the superior mesenteric artery and traversed the head of the pancreas. It was reanastomosed too slowly to permit survival. In still another, the superior mesenteric artery was adherent to the mass and was accidentally cut. In the fourth patient the portal vein was found to be heavily involved after we had been committed to resection. A segment was excised and the ends were resutured, the anastomosis remained patent, but the patient died of hepatorenal syndrome.

One of the gratifying aspects of the radical resection and the local excision of the common duct in which the Allen²² procedure was used has been the complete absence of cholangitis. Data on operative mortality are presented in Table I.

The late survival data of those patients undergoing local excisions of lesions of the ampulla are gratifying, the average being twenty-two months, with four of the five patients still alive. The outlook in the common duct obstructions proved to be less satisfactory, the mean survival being eight months. In the radical resections for whatever cause, the operative mortality was high enough to affect the mean survival rate considerably, the figure was three and one-half months (five months if the figures are derived from survivors of surgery alone) (see Table II).

Late survival in the group explored only or given palliative procedures has been partially studied, our follow-up data being incomplete. As will be seen in Table III, the mean survival in the patients with simple exploration for which we have information was only one month. In those given some palliation, it was but little better, three months.

TABLE I IMMEDIATE RESULTS OF SURGICAL PROCEDURES FOR NEOPLASTIC BILIARY OBSTRUCTION

PROCEDURES AND SITES OF LESIONS	NUMBER OF PATIENTS	SURGICAL DEATHS
Exploration only		
Pancreas	6	2 ¹
Gall bladder and common duct	1	1
Uncertain origin	2	0
Palliative procedures	14	3
Local resections		
Common bile duct	4 ²	1 ³
Ampulla of Vater	5	0
Radical pancreaticoduodenectomy		
Common bile duct	3	1 ⁴
Ampulla of Vater	3	1 ⁵
Head of pancreas	8 ⁶	2 ⁷
Total	46	11

¹One died on induction of anesthesia alone.

²One J. R. Paine, one O. H. Wangenstein.

³Patient died of hepatorenal syndrome.

⁴Pulmonary embolus two days postoperative.

⁵Superior mesenteric artery cut accidentally.

⁶One by J. R. Paine.

⁷One case of vascular anomaly, one case of heavy involvement of portal vein found only after commitment to excision, segment resected and anastomosis attempted, anastomosis functioned and remained patent (proved at post-mortem) but patient died of hepatorenal syndrome.

TABLE II. FOLLOW UP DATA ON PATIENTS WITH NEOPLASTIC BILIARY OBSTRUCTION

TYPE OF PROCEDURE	NUMBER SURVIVING SURGERY	SURVIVAL AND STATUS
Local excisions		
Common duct	3	Living and well 4½ mo Dead 1 yr
Ampulla	5	Dead 15 mo Living and well 36 mo Living and well 27 mo Living and well 9 mo Living 23 mo Dead 10 mo
Radical excisions		
Common duct	1	Living and well 3½ mo
Ampulla	3	Living and well 2 mo Living and well 1 mo Dead 8 mo
Pancreas	6	Living and well 12 mo Living 6 mo Dead 6 mo Dead 5 mo Dead 3½ mo Dead 3 mo

TABLE III FOLLOW UP DATA ON PATIENTS WITH NEOPLASTIC BILIARY OBSTRUCTION, SURVIVAL TIMES

PROCEDURE	NUMBER OF PATIENTS	MAXIMUM SURVIVAL	MEAN SURVIVAL
Exploration only	4	3 mo	1 mo
Palliation	12	11 mo	3 mo
Resections (local)			
Ampulla	5 ¹	36 mo	22 mo
Common duct	4 ²	15 mo	8 mo
Radical pancreaticoduodenectomies	14 ³	12 mo ⁴	3½ mo

¹Four living²One living and well³Five living⁴Living

Note Figures include patients who were surgical casualties

CONCLUSIONS

1 Our experience with forty-six patients with neoplastic biliary obstruction has been presented. Fourteen of these had radical pancreaticoduodenectomy, and nine had local excisions of the ampulla or common bile duct.

2 A procedure has been presented which we have evolved for the radical resections. For several reasons we consider it superior to any heretofore reported. The most important is the simplicity of the plan. Also important is the complete elimination of cholangitis in this series.

3 Thirteen new radical pancreaticoduodenectomies are added to the 104 cases already in the literature, one of which also came from this group.

4 Simple exploration carried a 23 per cent mortality in the nonresectable lesions and the survivors of surgery in this group lasted on the average a little less than three months.

5 Radical pancreaticoduodenectomy carried a 29 per cent mortality, mostly due to now-avoidable factors. Of the ten survivors five died in an average

of a little over five months, and five are living and well at periods up to twelve months

6 Local resections of lesions of the common duct or ampulla of Vater incurred a mortality rate of only 11 per cent. The ampullary local resections group has lost one patient out of five, and two of three patients with common duct resections to survive surgery are still living.

7 With the experience which has now been gained the mortality rate in surgery for tumors causing extrahepatic biliary obstruction may be expected to drop to less than 10 per cent.

REFERENCES

- 1 Whipple, A. O., Parsons, W. B., and Mullens, C. B. The Treatment of Carcinoma of the Ampulla of Vater, *Ann Surg* 102: 763, 1935.
- 2 Dragstedt, L. R. Some Physiologic Problems in Surgery of the Pancreas, *Ann Surg* 118: 591, 1943.
- 3 Watson, C. J. Studies of Urobilinogen, III. The Per Diem Excretion of Urobilinogen in the Common Forms of Jaundice and Disease of the Liver, *Arch Int Med* 59: 206, 1937.
- 4 Whipple, A. O. The Rationale of Radical Surgery for Cancer of the Pancreas and Ampullary Region, *Ann Surg* 114: 612, 1941.
- 5 Trimble, I. R., Parsons, J. W., and Sherman, C. P. A One stage Operation for the Cure of Carcinoma of the Ampulla of Vater and of the Head of the Pancreas, *Surg, Gynec & Obst* 73: 711, 1941.
- 6 Whipple, A. O., and Bauman, L. Observations on the Pathologic Physiology of the Insular and External Secretory Functions of the Human Pancreas, *Am J M Sc* 201: 629, 1941.
- 7 Hunt, V. C. Surgical Management of Carcinoma of the Ampulla of Vater and of the Perampullary Portion of the Duodenum, *Ann Surg* 114: 570, 1941.
- 8 Trautmann, M., Robbins, H. J., and Stewart, C. C. An Experimental Study of the Operation of Cholecystenterostomy, *Surg, Gynec & Obst* 44: 612, 1927.
- 9 Cole, W. H., and Reynolds, J. T. Resection of the Duodenum and Head of the Pancreas for Primary Carcinoma of the Head of the Pancreas and Ampulla of Vater, *SURGERY* 18: 133, 1945.
- 10 Wangensteen, O. H. Cholangitis Following Cholecystenterostomy, *Ann Surg* 87: 54, 1928.
- 11 Montgomery, M. L. The Influence of the External Secretion of the Pancreas on Lipid Metabolism, *Ann Surg* 114: 441, 1941.
- 12 Dennis, C. A Modified Whipple Operation for Carcinoma of the Head of the Pancreas, *SURGERY* 12: 201, 1942.
- 13 Brunschwig, A. One Stage Pancreaticoduodenectomy, *Surg, Gynec & Obst* 77: 581, 1943.
- 14 Dennis, C. Preoperative and Postoperative Care for the Bad Risk Patient, *Minnesota Med* 27: 538, 1944.
- 15 Varco, R. L. Preoperative Dietary Management for Surgical Patients, *Staff Meet Bull, Hosp Univ of Minnesota* 15: 196, 1944.
- 16 Whipple, A. O. Surgical Treatment of Carcinoma of the Ampullary Region and Head of the Pancreas, *Am J Surg* 40: 260, 1938.
- 17 Whipple, A. O. Discussion of paper by Dragstedt.²
- 18 Coffey, R. C. Pancreatoenterostomy and Pancreatectomy, *Ann Surg* 50: 1238, 1909.
- 19 Poth, E. J. The Implantation of the Pancreatic Duct Into the Gastrointestinal Tract, *SURGERY* 15: 693, 1944.
- 20 Varco, R. L. A Method of Implanting the Pancreatic Duct Into the Jejunum in the Whipple Operation for Carcinoma of the Head of the Pancreas, *SURGERY* 18: 569, 1945.
- 21 Orr, T. G. Pancreaticoduodenectomy for Carcinoma of the Ampulla and Ampullary Region, *SURGERY* 18: 144, 1945.
- 22 Allen, Arthur W. A Method of Reestablishing Continuity Between the Bile Ducts and the Gastrointestinal Tract, *Ann Surg* 121: 412, 1945.

eral days, suction decompression, frequent low enemas, and other nuisances. Again, several weeks later, barium studies reveal in a surprisingly great number of these patients a rather marked stenosis of the bowel at the point of anastomosis, which may or may not become of clinical significance later in the individual's

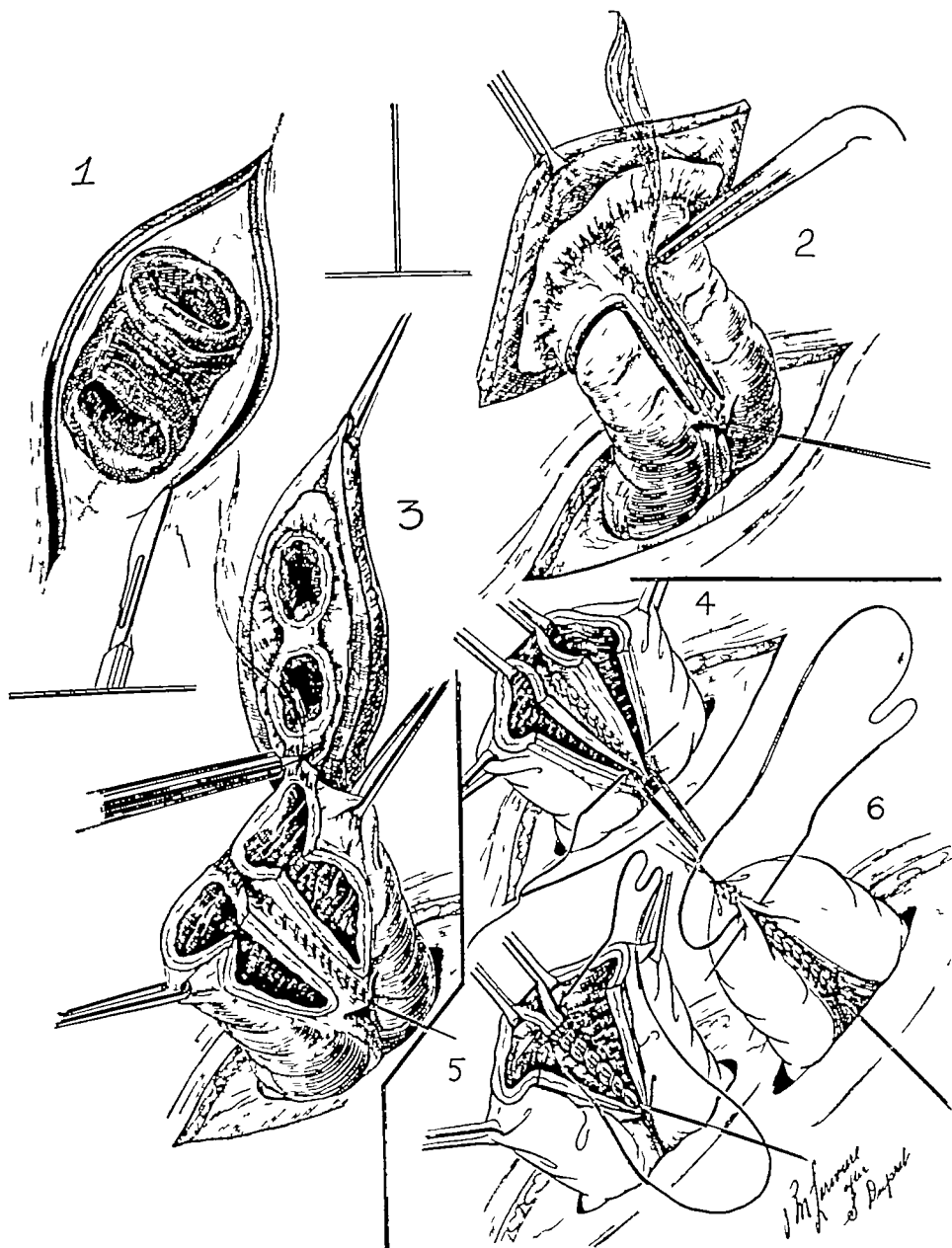


Fig 2—Pauchet technique of colostomy closure. The continuous suture shown in 5 is usually continued down the lateral aspect of the anastomosis as a continuous Connell stitch in our technique. Interrupted Halsted sutures of fine black silk are usually substituted for the continuous Lembert suture shown in 6. Cautery is not used in our technique. (From Maingot, Abdominal Operations Vol II New York N Y D Appleton Century Company p 1334)

life. We propose, therefore, to describe a method of colostomy closure which in our hands has satisfactorily surmounted these difficulties in twenty-two consecutive cases. The technique was first described by Victor Pauchet in 1934, and has thus far not found favor with American surgeons, either because of unfamiliarity or because of its apparent lack of simplicity.

TECHNIQUE

The operation embodies largely the principle of the Finney pyloroplasty, and consists briefly in encircling the colostomy stoma by an elliptical skin incision, leaving a cuff of skin about one-quarter inch around the mucosal edge. The incision is deepened in an anatomic manner by sharp dissection through all the layers of the abdominal wall down to the peritoneum, which is then deliberately opened along the medial aspect of the colostomy. The peritoneal incision is continued by sharp dissection so that it completely encircles and frees the afferent and efferent limbs of the colostomy. With gentle traction on the bowel, further mobilization is continued as far as is necessary to provide an adequate length of bowel for the anastomosis, and to permit, if necessary, resection of the colostomy or of segments of bowel deformed by secondary fistulas or stomata, extensive scarring or granulomatous masses. Proper mobilization permits complete delivery from the abdominal cavity of the afferent and efferent limbs of bowel to be used in the anastomosis. The wound edges and the peritoneal cavity are protected by two large saline packs tucked snugly down into the wound around the bowel. All subsequent surgical procedures are then carried on entirely outside the abdominal cavity and the operative wound. After such complications as bowel rotation and interposition of small bowel or omentum, etc., are corrected, and after resection of undesirable segments of bowel has been completed, the anastomosis is performed as shown in the illustrations (Fig. 2). Upon completion of the anastomosis the bowel is carefully replaced within the peritoneal cavity so as to avoid twisting or kinking, and the wound is then closed in layers without drainage. Depending on the individual desires of the surgeon, sulfonamide crystals may or may not be dusted into the wound, over the suture line in the bowel, and into the peritoneal cavity. It is our personal opinion that such solicitude is unnecessary. See Figs. 1 to 6.

RESULTS

The results following the employment of this procedure in twenty-two consecutive colostomy closures are presented in Table I.

COMMENT

In all of the patients in this series, thorough preparation of the bowel preoperatively with sulfasuxidine and a low residue diet was done. The effectiveness of sulfasuxidine preparation was not checked by stool cultures, but it was noted that for two or three days prior to operation the stools became soft, brownish yellow, and odorless, phenomena which have been described by many investigators. On the night before operation all patients received irrigations of 1,000 cc. of tap water in the afferent and efferent loops of the colostomy, follow-

TABLE I SIGNIFICANT FEATURES IN TWENTY TWO CONSECUTIVE COLOSTOMY CLOSURES BY PAUCHET TECHNIQUE

PATIENT	LOCATION OF COLOSTOMY	TYPE OF COLOSTOMY	ASSOCIATED DEFECTS AND COMPLICATIONS	SUITABLE FOR MIKULICZ CLOSURE?	ADDITIONAL SURGICAL PROCEDURES NECESSARY AT CLOSURE	POSTOPERATIVE COMPLICATIONS
E N	Sigmoid	Double barreled, no spur	Prolapsed distal loop	No	Reduction of prolapse	None
R P	Transverse colon	Exteriorization, no spur	None	No	None	None
E B	Transverse colon	Exteriorization, no spur	Large hernia at colostomy site	No	Extensive repair of abdominal wall	Postoperative incisional hemorrhage
G F	Transverse colon	Exteriorization, spur type	None	Yes	None	None
G C	Transverse colon	Exteriorization, spur type	None	Yes	None	None
O E	Sigmoid	Exteriorization, spur type	None	Yes	None	None
V G	Sigmoid	Exteriorization, spur type	Short spur rotation of loops	No	Correction of rotation	None
H H	Sigmoid	Double barreled, spur type	None	Yes	None	Rectal hemorrhage, third postoperative day due to deficiency controlled with vitamin K
L G	Sigmoid	Double barreled, spur type	Subcutaneous herniation, both loops	No	Repair of musculofascial defect	None
L M	Transverse colon	Tangential, loop type	No spur, adherent loops small bowel	No	Separation of adherent small bowel	None
F T	Descending colon	Exteriorization type	Multiple stomata, bowel rotation, fecal fistula from afferent loop	No	Resection of colostomy and four inches of colon	None
J F	Transverse colon	Exteriorization with spur	Hepatocolic fistula	No	Closure of hepatocolic fistula, resection of colostomy	None

ing which they were given 8 c c of paregoric by mouth. This dose was repeated on the morning of operation. Invariably, at operation the bowel was found to be completely and shiningly clean, containing no fecal matter or residue of any kind. Primary wound closure without drainage was performed in all but one patient, in whom a small Penrose drain was left for thirty-six hours down to the site of closure of an associated hepatocolic fistula. All wounds healed kindly without induration or reaction in every case but one, which will be discussed later. There were no evidences of wound infection or drainage in any patient.

The patients were allowed to take a full liquid diet as soon as they returned from the operating room. All were ambulatory on the first postoperative day, and had normal bowel movements without cramping, enemas, or catharsis on the second or third postoperative days. All patients were taking a regular house diet on the third postoperative day. In no case was postoperative suction decompression employed or thought necessary. Sulfasuxidine was continued for

TABLE I—CONT'D

PATIENT	LOCATION OF COLOSTOMY	TYPE OF COLOSTOMY	ASSOCIATED DEFECTS AND COMPLICATIONS	SUITABLE FOR MUCULIC? CLOSURE?	ADDITIONAL SURGICAL PROCEDURES NECESSARY AT CLOSURE	POSTOPERATIVE COMPLICATIONS
F B	Sigmoid	Double bar reled, spur type	Short spur	No	None	None
D J	Sigmoid	Exteriorization, no spur	Mucosal herniation, no spur bowel rotation, accessory stoma in proximal loop, extensive scarring	No	Resection of colostomy and 6 inches of colon	None
E R	Sigmoid	Double bar reled, spur type	None	No	None	None
A. K.	Sigmoid	Double bar reled, spur type	None	Yes	None	None
B B	Sigmoid	Tangential loop type	No spur, stenosis and scarring	No	None	None
J W	Sigmoid	Double bar reled, spur type	None	Yes	None	None
B D	Sigmoid	Double bar reled, spur type	None	Yes	None	None
P C	Sigmoid	Tangential	No spur	No	None	None
C E	Sigmoid	Double bar reled, spur type	None	Yes	None	None
J E	Sigmoid	Double bar reled, spur type	None	Yes	None	None

five days postoperatively in two patients, in whom extensive bowel resection had been necessary. None of the remaining nineteen received sulfasuxidine postoperatively. There were no instances of failure or partial reopening of the closure. Barium studies done in each case from three to four weeks postoperatively revealed extremely adequate, and at times very large, bowel lumens at the site of anastomosis (Figs 3 and 4).

DISCUSSION

The method of colostomy closure originally described by Pauchet was intended solely for reconstruction operations on the left colon, especially in the region of the sigmoid. Our experience has extended the application of the procedure to the transverse colon as far proximally as the hepatic flexure. We have not employed the method for reconstruction of the right colon since in this location resection and end-to-end anastomosis leaves nothing to be desired because of the anatomic characteristics of the bowel and the fluid nature of its contents. The advantages of the method as we see it, are as follows:

1. In common with resection and end-to-end anastomosis, the Pauchet technique of colostomy closure in one stage eliminates the waste of time and the

A*B**C**D*

Fig 3 A to D—Barium studies of four typical cases four weeks postoperatively showing ample lumens obtained following colostomy closure by Pauchet technique

dangers entailed in the crushing of a spur which may be badly formed, short, defective or actually absent

2 The actual surgical procedures upon the bowel itself, including resection of undesirable bowel anastomosis, etc., are carried on outside of the abdominal cavity and in fact, for the most part, outside of the operative incision

A



B

Fig 4 A and B—Fixed autopsy specimen of colon in which a Pauchet colostomy closure had been done two months earlier on a patient with severe bilateral renal lithiasis and infection, uremia and hemiplegia. Closure was done simply as a palliative procedure to make the patient's last few months of life more comfortable and to relieve family of nursing care associated with colostomy. Patient died of inanition following status epilepticus A, serosal aspect B mucosal aspect.

3 A safe method of intraperitoneal closure is provided making possible a thorough anatomic repair of the operative incision, in layers, without drainage, resulting in a firm, well-healed abdominal wall, in which the development of hernia is extremely unlikely

4 The method is extremely adaptable to the closure of defective, deformed, or otherwise complicated colostomies (Fig 5)

5 An adequate even generous, lumen is provided at the site of anastomosis (Fig 3)



Fig 5—Showing adaptability of Pauchet technique to closure of complicated colostomies. A, Accessory stoma and fecal fistula involving distal limb of colostomy. B Case in which 180° rotation had occurred with extensive scarring and deformity of colostomy. Dotted lines in each case indicate levels of resection of colostomy and incisions for Pauchet anastomosis

6 The postoperative morbidity is minimal, early ambulation and early feedings are permitted, and such postoperative nuisances as gas pains, partial obstruction, suction decompression, and the withholding of food are so far unknown

7 It is suggested that the Pauchet procedure may well supplant the second stage of the obstructive resection for carcinoma of the sigmoid

There are several objections to the method which must be mentioned. First of all, it is somewhat more time consuming than the standard Paul-Mikulicz procedure, although with experience the entire operation from beginning to end should consume no more than thirty minutes. When the procedure is complicated by the necessity for resection of a segment of bowel, more time is needed

However, with fairly extensive resections of from six to eight inches of scarred, distorted and adherent bowel the total operating time has not exceeded ninety minutes, and is usually about sixty minutes.

Second, as compared to simpler methods of anastomosis or closure, such as end-to-end suture, or the Paul-Mikulicz procedure, it is apparent that an excessive amount of suturing must be done, and that a rather long suture line will result which theoretically enhances the possibility of leakage. This theoretic possibility has not become an actuality in our experience. These bad features are, we think more than compensated for by the fact that, with the extremely generous lumens which are possible with this method, the surgeon can make a very firm, leakproof anastomosis, without fear of obstruction or stricture, by turning in a fairly large cuff of bowel wall all around, using two, or even three, layers of sutures.



Fig 6—Barium study done three weeks after operation demonstrating a common error in Pauchet closure. Note large lumen, but also distal kinking due to rotation of gut caused by (a) using too much bowel in an effort to make unnecessarily large lumen (b) making anastomosis medially rather than laterally as described.

In making anastomoses by this method certain precautions are necessary. The surgeon should beware of utilizing long segments of bowel in an effort to create an unnaturally and unnecessarily large lumen. If this is done, kinking or torsion may result just proximal and just distal to the anastomosis when the bowel is replaced within the peritoneal cavity. This occurred to a minor degree in one of our patients, but fortunately caused no apparent discomfort or complications (Fig 6). It is usually preferable to follow the original technique of Pauchet and make the anastomosis laterally, reflecting the mesocolon medially toward the abdominal cavity. This prevents the development of tension when

the last or outer suture layers are being placed. If one encounters at operation a spur which was previously formed by rotating the anterior taeniae of the two limbs medially in the customary manner, this should be thoroughly disconnected. The bowel should then be rotated laterally and the anastomosis made laterally, as described. After the incisions in the bowel wall have been thoroughly developed and are ready for suture, the cut edges should be accurately aligned by means of Allis clamps. If this is not carefully done, serious distortion of the suture line may result.

Two interesting postoperative complications deserve to be mentioned. In one patient rather extensive rectal bleeding occurred on the second postoperative day. Prothrombin determinations revealed an extremely low level of circulating prothrombin (less than 10 per cent) which was quickly corrected by the intravenous administration of 2-methyl-1,4-naphthoquinone with prompt, complete, and permanent cessation of the bleeding within two hours. In the second case an extensive repair of a musculofascial defect in the abdominal wall was done. This patient developed a postoperative incisional hemorrhage on the second day. In this patient, also, an extremely low prothrombin level was discovered which, when corrected by intravenous administration of 2-methyl-1,4-naphthoquinone, resulted in prompt and permanent cessation of bleeding. In both of these cases, routine studies had shown normal prothrombin levels at the beginning of sulfasuxidine therapy seven days prior to operation. It is felt that the marked reduction of vitamin K-synthesizing colonic bacteria brought about by sulfasuxidine was partly responsible for these hemorrhagic phenomena. Since that time we have routinely administered synthetic vitamin K by mouth, both preoperatively and postoperatively, in all patients receiving sulfasuxidine therapy and have encountered no subsequent instances of hemorrhage.

SUMMARY

1 A method of colostomy closure in one stage is described which is extremely adaptable to the closure of many types of orthodox, unorthodox, and defective colostomies in the transverse, descending, and sigmoid colons.

2 A series of twenty-two consecutive colostomy closures by this method, with no failures, and with minimal morbidity and complications, is presented.

3 This procedure is suggested as a substitute for the second stage of an obstructive resection for carcinoma of the sigmoid by the Paul-Mikulicz technique.

REFERENCES

- Dixon, C. F., and Benson, R. E. Closure of Colonic Stomas, *Ann Surg* 120: 562, 1944.
 Dor, M. J. La Fermeture Des Anus Iliaques Gauches, *J de méd de Paris* 37: 659, 1938.
 Finochietto, R. Colostomia, *Seccion de Espolon, Prensa méd argent* 46: 2206, 1943.
 Gordon Taylor, G. Second Thoughts on the Abdominal Surgery of "Total War," a Review of Over 1300 Cases, *Brit J Surg* 32: 247, 1944.
 Howser, J. W. An Improved Technique for Closure of a Loop Colostomy, *Am J Surg* 63: 187, 1944.
 Keene, C. H. Colostomies, *Bull U S Army M Dept. (No 86)* 115, 1945.
 Lockhart Mummery, J. P. Discussion on Methods of Making and Closing Colostomy Openings, *Proc Roy Soc Med, London* 10: 135, 1916-1917.
 Idem. The Closure of Colostomy Openings, *Lancet* 1: 554, 1917.
 Morgan, C. N. Wounds of the Colon, *Brit J Surg* 32: 337, 1945.

- Mayo, C W, and Schliche, C P That Hazardous Eminence, the Colostomy Spur, Am J Surg 58 29, 1942
- Mangot, R Abdominal Operations, Vol II, New York, N Y, D Appleton Century Company, p 1334 1335
- Morgan, C N Wounds of the Rectum, Surg, Gynec & Obst 81 56, 1945
- Ogilvie, W H The Forward Surgery of Abdominal Wounds, Lancet 1 555, 1944
- Idem Abdominal Wounds in the Western Desert, Surg, Gynec & Obst 78 225, 1944
- Pauchet, V, and LeGac, P Fermeture d'un Anus Artificiel Gauche Consecutif a une Colectomie Gauche Segmentaire, La Pratique Chirurgicale Illustree, Vol 19, Paris, Gaston Doin & Cie, p 130
- Pemberton, J de J, and Black B M Delayed Closure of Incisions Made at Closure of Colonic Stomas, Surg, Gynec & Obst 76 385, 1943
- Poth, E J, and Knottis, T L The Clinical Use of Succinyl Sulfathiazole, Arch Surg 44 208, 1942
- Poth, E J Succinyl Sulfathiazole and Phthalyl Sulfathiazole in Surgery of the Colon, SURGERY 17 773, 1945
- Shallow, T A, Eger, S A, and Tourish, W J An Improved Method for Extra Peritoneal Closure of Colostomy, SURGERY 18 166, 1945

THE TREATMENT OF PATIENTS WITH ACHALASIA BY ESOPHAGOGASTROSTOMY

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DERANGEMENT of function of the lower esophagus with dilatation of the upper esophagus and delayed passage or retention of food is a disease that has been described in the literature under various titles. The terms commonly used are cardiospasm or achalasia. Descriptive titles such as ectasia, idiopathic or paralytic dilatation of the esophagus, and megacosophagus have also been employed to emphasize enlargement of the upper esophagus. The condition has usually been treated by diet, drugs, and intraesophageal dilatation. Progressive dysphagia and starvation have occasionally necessitated surgical intervention for relief of obstruction.

Different operations have been proposed for this disease. Those designed to enlarge the opening between the esophagus and stomach are of interest to this report. Two of these operations avoided opening into the lumen of the esophagus. The first was performed in 1900 by Mikulicz¹ and consisted of a transabdominal manual and instrumental dilation of the cardia and lower esophagus. The second was used in 1914 by Heller². Two longitudinal incisions, one anterior and one posterior, were made along the lower esophagus and down to the stomach. The muscles were divided but the mucosa was left intact. The operative procedure is similar to that used for congenital pyloric stenosis.

The first operation for achalasia that opened into the esophagus was evidently performed by Wendel³. In 1910 he made a single longitudinal incision into the lumen of the lower esophagus and continued it through the anterior wall of the cardia of the stomach. This longitudinal incision was then retracted laterally and sutured transversely to perform a cardioplasty. Heyrovsky⁴ later reported an open operation also first performed in 1910 that brought the dilated portion of the esophagus down through the diaphragm. A side-to-side anastomosis was then made between the esophagus and the cardia of the stomach. The terminal portion of the esophagus, which was not enlarged, was not disturbed. In 1913 Lambert⁵ enlarged the opening between the dilated esophagus and the stomach by inserting one blade of a long spur-crushing clamp into the lumen of either organ and crushing the adjacent walls. The clamp was brought out through a temporary gastrostomy and later removed. Grondahl⁶ in 1916 was evidently the first to modify the Heyrovsky esophagogastrostomy by using a technique similar to that employed earlier by Finney⁷ for gastroduodenostomy. Bull,⁸ Womack,⁹ Ochsner and DeBailey,^{10, 11} Gray and Skinner,¹² Scott,¹³ Clagett, Moersch, and Fischer,¹⁴ and others have discussed the use of this operation for achalasia. Favorable results have been reported.

This presentation deals with the use of esophagogastrostomy in patients with achalasia. For convenience the operation will be referred to as cardio-

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plasty. It was performed through an upper abdominal midline incision. After dividing the left triangular ligament and retracting the left lobe of the liver, the lower portion of the esophagus was mobilized and delivered into the abdomen. Care was taken to bring down the dilated segment. In Fig 1 is illustrated the importance of extending the incision in the esophagus well up into the area of enlargement. A normal-sized segment of the lower esophagus as long as that illustrated is frequently observed between the stomach and the enlarged and thickened upper esophagus. An incision well into the enlarged area is necessary to insure adequate drainage. Fine interrupted catgut sutures were used for the anastomosis. There has been no operative mortality.

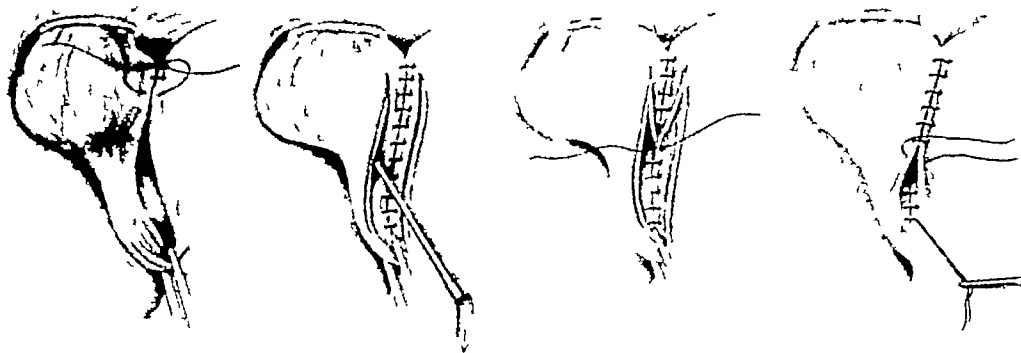


Fig 1—The drawings illustrate the importance of extending the incision for esophagogastrostomy or cardioplasty through the stomach and small lower esophagus into the enlarged portion of the esophagus to insure adequate drainage. Suction rather than the use of temporary clamps or ties about the esophagus facilitates upward extension of the incision.

Brief case histories of nine patients treated by this operation will be presented and changes in the size of the esophagus will be described. Also the effect of sympathectomy performed for hypertension, and the effect of vagotomy performed for peptic ulcer on the function of the esophagus will be discussed.

CASE REPORTS

CASE 1—E. R., a white man, was 47 years of age at the time of operation and had had dysphagia for nine months. He had lost forty of his usual 160 pounds of body weight. Six months before operation he was hospitalized for five weeks and treated by belladonna, diet, and repeated dilatations of the contracted lower esophagus. There was temporary relief of dysphagia with a gain of ten pounds in weight. Four months before operation swallowing became more difficult and episodes of regurgitation occurred. During the last ten days liquids passed into the stomach with difficulty. X-ray revealed an enlarged upper esophagus and a smooth narrow lumen near the cardia.

Transabdominal cardioplasty was performed July 29, 1941. Convalescence was uneventful. The patient ate a full house diet after eight days. Two weeks later a large piece of beefsteak completely obstructed the esophagus. Esophagoscopy was performed and the meat was removed. The patient then ate regularly and maintained a weight of around 170 pounds. Fluoroscopic examination until June, 1945. At this time moderate dysphagia again developed. Esophagoscopy examination revealed rapid emptying of an esophagus of normal size. Dilatation of this region was performed four times. Symptoms were relieved and the patient has continued to eat normally.

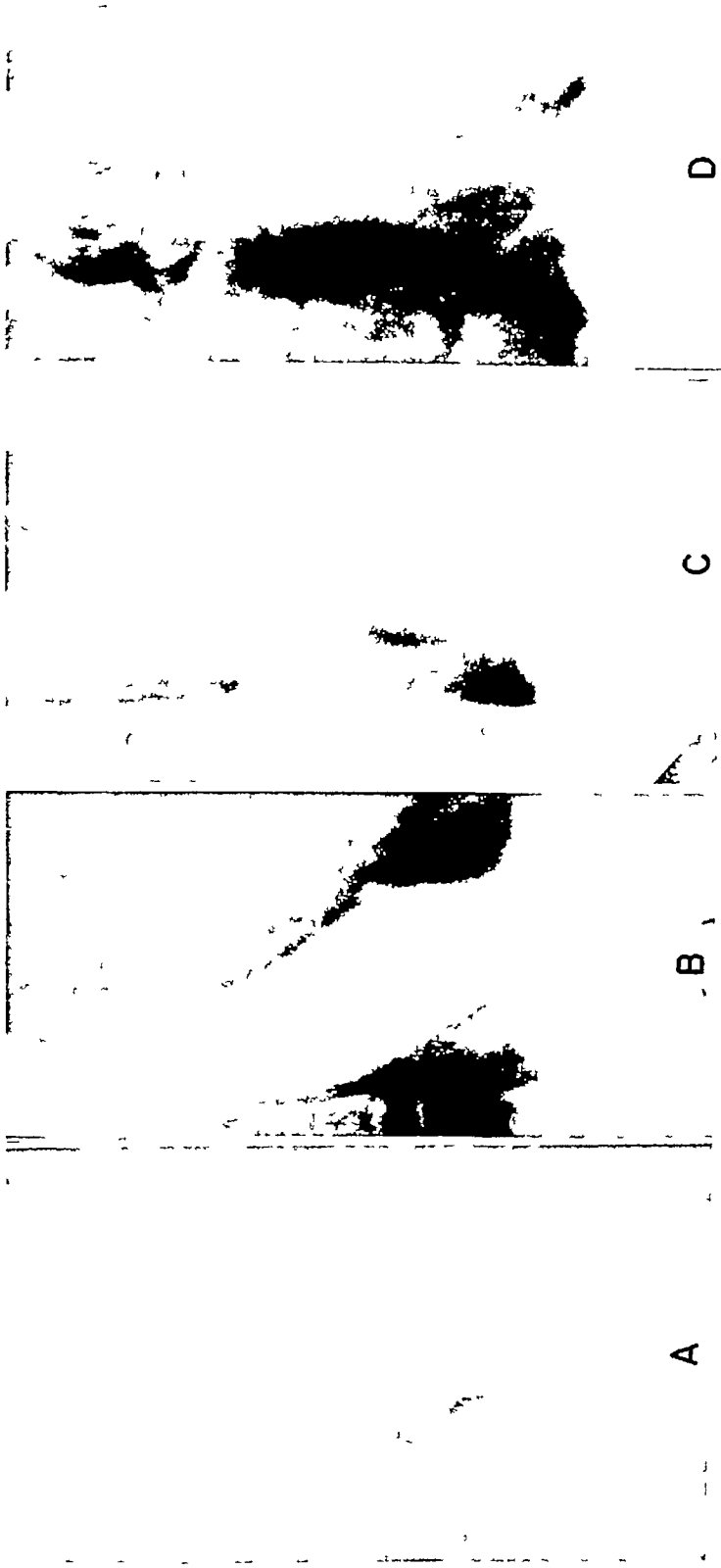


Fig 2 (Case 2) —Roentgenograms reveal the appearance of the esophagus before cardioplasty (A), Progressive reduction of size is evident after thirteen days (B), nineteen months (C), and thirty-four months (D)

CASE 2—H W, a white man, was 21 years of age at the time of operation. He had had dysphagia for three years. Dilatations of the lower esophagus were begun when symptoms developed, and continued two or three times a month for one and one half years. Relief of symptoms after each dilatation lasted one or two days. Dilatations were then performed at less frequent intervals up to the time of operation. During the last year drugs and psychotherapy were also employed. Regurgitation occurred several times a day. The weight of the patient decreased from around 132 to 127 pounds. Examination of the esophagus by x ray revealed marked dilatation of the upper portion and smooth narrowing of the cardia.

Cardioplasty was performed March 5, 1913. Convalescence was uneventful. Within ten days the patient tolerated a regular diet. He did not have dysphagia for twenty five months. Difficulty then occurred on several occasions after eating tough steak. Although fluoroscopy at this time revealed that barium passed readily, esophago-scopy revealed granulation tissue at the site of the anastomosis. This was cauterized. Three dilatations at intervals of one month again effected relief of dysphagia. Thirty three months after operation an anemia was noted and three blood transfusions were given by a local physician. There was no history of melena or hematemesis. The patient's weight increased to 146 pounds. X ray examinations (Fig 2) revealed decrease in the size of the esophagus until at thirty four months the diameter was normal.

CASE 3—E H, a white girl, was 17 years of age and weighed 105 pounds at the time of operation. Difficulty in swallowing had been present since birth. The first symptom was a choking sensation, that was occasionally associated with dyspnea, after eating. During childhood the patient would drink water, press on the lower neck, and occasionally vomit to relieve this choking sensation. During the last five years symptoms progressively became more severe. Regurgitation of some food occurred after each meal. Belladonna and other antispasmodic drugs, and on three occasions dilatation of the lower esophagus, failed to relieve symptoms appreciably. X ray revealed marked dilatation of the esophagus and obstruction to the passage of barium.

Cardioplasty was performed, June 8, 1913. At operation a band of fibrous tissue was discovered across the esophagus near the stomach. This did not seem to cause obstruction. It was divided and the anastomosis was completed. Convalescence was uneventful. Symptoms of dysphagia were relieved. Four months after operation an epigastric burning sensation was noticed after meals. This was relieved by taking soda. During the next two months fatigue developed and the patient was found to have a hemoglobin of 39 per cent. Esophagoscopy revealed that the anastomosis was adequately open but that there was friable granulation tissue at its upper end. There was no history of melena or hematemesis. A benzidine test revealed blood in the first stools. The anemia responded to treatment by ferrous and vitamins. Later, during the time of the patient's marriage, occasional mild dysphagia was again noted. Dilatation was performed without relief. The dysphagia cleared up spontaneously shortly after the wedding ceremony. The patient's weight increased to 115 pounds. There was a change in size of the esophagus evident during x ray examinations. Seven months after operation the caliber was normal and there was no delay in the passage of barium into the stomach. The findings thirty one months after operation were the same.

CASE 4—T O, a 50 year old white man, had had dysphagia and a choking sensation for three years. Regurgitation occurred frequently. During the last year there was a decrease in weight from 125 to 105 pounds. Dysphagia was more severe during this year and regurgitation occurred after most meals. Treatment by antispasmodic drugs and sedatives was ineffectual. Esophagoscopy and x ray examination revealed dilatation and delay of emptying of the esophagus.

Cardioplasty was performed Nov 6, 1913. A diseased gall bladder was also removed. The only difficulty in swallowing since operation has been an occasional delay of passage of lean meat. Regurgitation has occurred on two occasions. The patient eats heartily and has gained 27 pounds. X ray examinations reveal the change in size of the esophagus. Thirty seven months after operation the diameter was normal and barium passed freely. A dilatation was nevertheless performed to aid the swallowing of lean meat.

CASE 5—O J, a colored girl, was 16 years of age at the time of operation and had had difficulty in swallowing food and frequent regurgitation for four and one half years. During the last year before operation her weight decreased from 113 to 93 pounds. Treatment before operation consisted of psychotherapy, sedatives, belladonna, and, on five occasions, dilatation of the lower esophagus. X ray revealed massive enlargement of the upper esophagus with a smooth contraction of the lower end that delayed emptying.

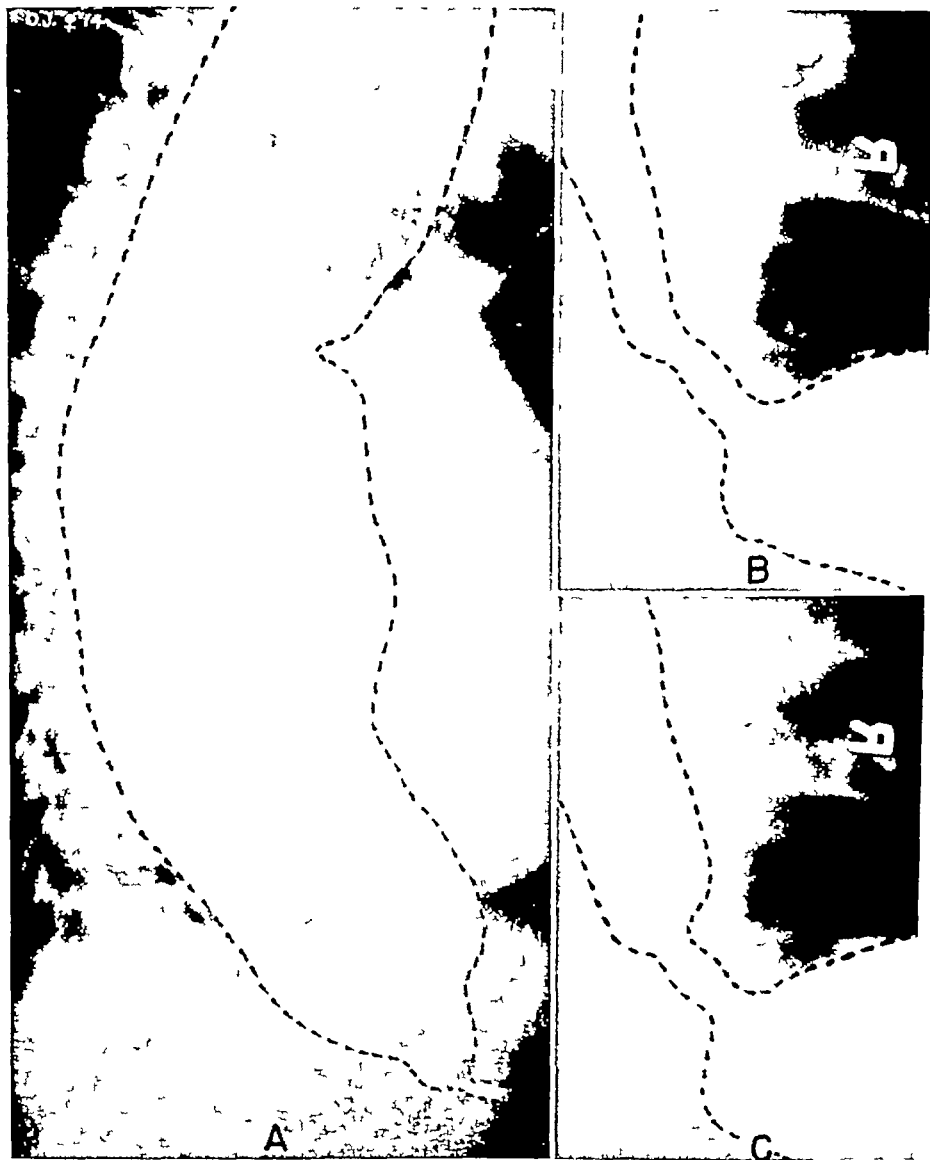


Fig 3 (Case 5)—The dilatation of the esophagus present before operation (A) has reduced almost to normal eleven months after cardioplasty (B). Forced swallowing (C) reveals the site of the anastomosis at this time.

Cardioplasty was performed Feb 8, 1944. The postoperative convalescence was uneventful. Dysphagia was relieved and within five months the weight was 136 pounds. Fig 3 reveals the appearance of the esophagus by x ray before operation and two views of the appearance of the lower esophagus and the anastomosis eleven months afterward. Fluoroscopy

at this later date revealed rapid emptying and little dilatation. The local physician reported that, twenty three months after operation, the patient was eating regularly without difficulty.

CASE 6—M B, a colored woman, was 66 years of age at the time of operation. She complained that she had not been able to keep food down for thirteen years. Prior to this period her weight ranged around 270 pounds. During the thirteen years there was a weight loss of about ten pounds a year. During the month before operation the patient remained entirely unable to conserve her strength. The weight on admission was 90 pounds. An esophagoscopy was attempted but discontinued because of massive regurgitation. X ray revealed enlargement of the esophagus to an approximate diameter of three and one half inches and marked delay of passage of barium.

Cardioplasty was performed Dec 26, 1944. The postoperative course was uneventful. Fourteen days after operation a full house diet was well tolerated. The patient gained weight rapidly and ate without difficulty. Seven months after operation she returned because of pain in the left shoulder. Examination revealed an osteolytic lesion in the sixth cervical vertebra. Fluoroscopy revealed some dilatation of the esophagus. There were no pulmonary metastases. The patient did not return for further examination or treatment. The local physician reported that she died at home five months later with a large tumor mass in the left neck. Emaciation developed during the last two months and difficulty in swallowing developed during the last ten days.

CASE 7—C F, a colored woman, was 49 years of age at the time of operation. Dysphagia had been troublesome for six years. Two years before operation substernal discomfort developed with each meal. It was relieved by taking soda or drinking several glasses of water. Beginning one year before operation, swallowing produced a choking sensation and regurgitation occurred frequently. Esophagoscopy and x ray revealed enlargement of the esophagus with angulation to the right and obstruction to the passage of barium. The patient had lost weight and at the time of operation weighed 116 pounds.

Cardioplasty was performed, May 12, 1945. There was an uneventful convalescence. During the eight months that have elapsed since operation, the patient has eaten with little difficulty. There has been no regurgitation, although at times the patient describes a rancid taste in the mouth. She complains only that strong coffee goes down slowly. There has been a gain of twelve pounds in weight. Examinations of the esophagus by x ray reveal that there has been no appreciable decrease in the degree of dilatation or improvement in the rate of passage of barium after the operation. The narrowing of the esophagus, which was below the level of the diaphragm before operation, is now definitely above the diaphragm and above the level of the anastomosis. Dilatation of this area has been recommended.

CASE 8—T R, a colored man, was 29 years of age at the time of operation. Dysphagia began at the age of 14. X ray examination seven months after the development of the illness revealed moderate dilatation of the esophagus and marked delay in the passage of barium. Esophagoscopy then confirmed a diagnosis of achalasia. Three dilatations effected some relief of symptoms. The relief lasted for three months. The patient was next examined at the age of 29. During the fifteen year interval there had been continuous difficulty in swallowing. The patient forced all of his food down by drinking water. He frequently regurgitated and had to eat again. On two occasions emesis contained blood. Twice during the three months before operation the esophagus blocked completely for several days. X ray revealed a dilated esophagus. At the time of operation the weight was 134 pounds.

Cardioplasty was performed, Aug 4, 1945. The postoperative course was uneventful. During the six months that have elapsed since operation, the patient has gained nine pounds. He states that he can eat anything and that he experiences no difficulty. X ray examination shows that the esophagus three months and six months after operation is only slightly enlarged.

CASE 9—M D, a colored woman, was 22 years of age at the time of operation. She described the first symptom as a sensation of fullness in the throat. This was noticed one year before operation. The tonsils and adenoids were removed by a local physician without relief. During the year she was able to eat solid foods by forcing them down with water. Dysphagia became more severe and regurgitation occurred frequently. When referred to

the hospital she could swallow only liquids. Esophagoscopy and x-ray revealed great enlargement of the upper esophagus and delay of passage of barium. The patient had lost weight from 124 to 105 pounds.

Cardioplasty was performed, Oct 17, 1945. The postoperative course was uneventful. During the four months that have elapsed since operation the patient has eaten regular foods without difficulty and regained her usual weight. X-ray examination at this time reveals that the esophagus is reduced in size, although not yet normal.

SYMPATHECTOMY OF THE ENTIRE ESOPHAGUS

Subtotal to total paravertebral sympathectomy, splanchnicectomy, and celiac ganglionectomy¹⁵ has now been carried out through a transthoracic approach in forty-nine patients as a treatment for hypertension. This procedure also removes the sympathetic nerve supply to the entire esophagus. The forty-nine patients have been followed several months to five and one-half years. The operation has not produced dysphagia or other symptoms of abnormal function of the esophagus. Templeton¹⁶ studied the esophagi of eight of these patients by barium and fluoroscopy. Since then ten additional patients have also been studied by fluoroscopy and there has been no evidence of abnormal function.

VAGOTOMY OF THE LOWER ESOPHAGUS

Dragstedt and Schaefer¹⁷ have described a technique for removing the vagus nerves and branches about the lower esophagus that they have used as a treatment for peptic ulcer. This approach has been used for peptic ulcer in this hospital in twenty-seven patients now observed two to nineteen months. Examination of the esophagus and stomach by barium, x-ray, and fluoroscopy before and at intervals after operation has revealed no change in function. Patients have not developed dysphagia or other difficulty in swallowing. The motility of the stomach itself is decreased after vagotomy.

DISCUSSION

Various theories have been advanced to explain derangement of function of the esophagus and dilatation of the type described in the cases reported. These theories have been adequately reviewed by Bull,⁸ Sturtevant,¹⁸ Walton,¹⁹ Womack,⁹ Ochsner and DeBakey,¹⁰ Gray and Skinner,¹² Scott,¹³ Clagett, Moersch, and Fischer,¹⁴ and others and will not be discussed in detail. The relationship between the observations in the patients described and the theories of causation of the disorder are of interest.

Dilatation of the esophagus, megaesophagus, and elongation and kinking of the esophagus, dolicho-esophagus, have been considered primary factors in the disease. The possibility that the dilatation is acquired and results from atony or paralysis of the esophagus, esophagitis, or degenerative changes in the vagus nerves has received little support. Bull⁸ credited von Hager and Bard with the suggestion that dilatation of the esophagus might be a congenital malformation similar to megacolon or Hirschsprung's disease. Lendrum,²⁰ however, studied autopsy material and stated that kinking of the esophagus of the type now called dolicho-esophagus was absent in all instances of early moderate dilatation and "can evidently occur only in cases of very old cardiospasm which there has been lengthening as well as dilatation." Most of the reports published on the results of medical or surgical treatment have described c

moderate decrease in the degree of enlargement Plummer²¹ reported ninety-one patients treated by his hydrostatic dilator and stated that in three the esophagus returned to normal size

A definite change in size of the esophagus after cardioplasty has occurred in eight of our nine cases Four gradually decreased to a normal size, seven, thirty-four, thirty-seven, and fifty-three months, respectively, after operation Two at three and eleven months were almost normal and two at ten days and three months had a significant reduction in size One patient had no relief of obstruction and no decrease in size of the esophagus These observations indicate to us that the dilatation in these cases was largely a result of chronic obstruction and therefore reducible by relief of obstruction They do not indicate that in these cases the dilatation was of an idiopathic or congenital irreversible nature

Cardiospasm has long been a popular term used to describe derangement of function of the esophagus being discussed von Mikulicz¹ and Meltzer²² probably originated the concept that a spasm at the lower end of the esophagus caused the disorder Sturtevant¹⁸ reviewed this literature and credited Lockwood with the suggestion that reflex irritation of the vagus nerves may be responsible Lendum²⁰ reviewed the literature indicating that cardiospasm might be associated with diverticulum of the esophagus, asthma, and more commonly with peptic ulcer There were two healed duodenal ulcers in his thirteen autopsies It is evident that emotional tension has at times temporarily aggravated symptoms in our nine patients The disease of the gall bladder present in one of the patients described (Case 4) may also have reflexly influenced the degree of obstruction There is, however, no evidence that emotional tension or reflex stimulation from abdominal disease caused the abnormality of function of the esophagus Ochsner and DeBakey¹⁰ found in the literature descriptions of eleven patients treated by vagotomy The results were death in three, recurrence in seven, and improvement in one

Rieder,²³ Knight,²⁴ Knight and Adamson,²⁵ and Feigelson²⁶ found that vagotomy in experimental animals produced a condition like that of "cardiospasm" or "achalasia" Our observations in twenty-seven patients before and after vagotomy for peptic ulcer revealed no significant disturbance of the function of the esophagus during the swallowing of food or barium

Knight²⁷ also observed that sympathectomy in animals prevented the obstruction at the cardia that they believed was produced by vagotomy and advocated sympathectomy for "achalasia" Ochsner and DeBakey¹⁰ reviewed reports of sympathectomy for "achalasia" including their own cases and stated that the results were not impressive Our observations on the function of the normal esophagus after complete sympathetic denervation for hypertension have not demonstrated any significant change of function

Scott and Morton²⁸ proposed spinal anesthesia as a test for overactivity of the sympathetic nerve supply to the colon Telford and Simmons²⁹ and Scott¹⁵ have reported improvement in "achalasia" or "cardiospasm" during and after spinal anesthesia Interpretation of their results is difficult because of the multiplicity of the immediate changes effected by spinal anesthesia and the established difference between an acute and a chronic denervation of many body

structures The observation, that chronic denervation of the esophagus of patients by sympathectomy or vagotomy does not appreciably alter peristalsis, supports the view that the myenteric plexus easily accomplishes motility by itself and may be only partially regulated by sympathetic and parasympathetic nerve impulses

There are two major objections to the theory that there was a spasm of the lower esophagus in our nine cases One is that of the nine patients none described pain referred from the lower esophagus, such as would be expected in spasm The other objection is that examination during operation in all patients and biopsy in four revealed hypertrophy and thickening of the wall of the enlarged portion of the esophagus but not of the narrower portion The narrower portion was elastic and grossly did not appear spastic

Observations at the time of operation revealed that the esophageal hiatus of the diaphragm was adequately open Since the junction of the small and the enlarged portion of the esophagus occurred at various levels and not always at the level of the hiatus it seems unlikely that a "diaphragmatic pinchcock" as described by Jackson³⁰ could have caused the disorder

The term achalasia evidently originated in Guy's Hospital in London around 1913 when Hurst³¹ investigated a patient and found that a rubber tube filled with mercury could be dropped through the esophagus into the stomach and withdrawn without meeting spasm or other appreciable resistance He concluded from this and other studies that obstruction to the passage of food was not caused by cardiospasm but rather by "absence of relaxation of the sphincter" This sphincter he described as being normally about one inch in length He stated that this sphincter is generally located at the level of the hiatus although it is occasionally lower and is rarely entirely thoracic Rake³² examined autopsy specimens from three patients with achalasia and found destruction of the ganglia and connecting nerves of Auerbach's plexus in the region of the sphincter and to a lesser degree in the dilated portion of the esophagus This he believed was caused by inflammation and might be the primary lesion in achalasia Lendrum²⁰ examined the myenteric plexus of the cardia of the esophagi in autopsy material from fifty-eight adults with grossly normal esophagi and stomachs and compared the findings with similar material from thirteen patients with achalasia He observed that in each of the thirteen there was a striking loss or complete absence of ganglion cells from the myenteric plexus The loss was as great in the undilated neck at the cardia as it was in the dilated portions Lendrum also observed that there is a compensatory dilatation of the upper esophagus, and that as it becomes prodigiously dilated it is also stretched lengthwise so that bends and kinks may occur

Unfortunately studies of the myenteric plexus were not performed during our study of nine patients treated by cardioplasty It is, therefore, not possible to comment on these important histologic studies

CONCLUSION

The evidence presented has led to agreement with many other authors that the term achalasia is proper for many patients with derangement of function of the lower esophagus It seems to apply, although largely from negative evidence,

to the nine patients described. It also seems probable that the enlargement of the upper portions of the esophagus is produced by obstruction and retention and may be obviated by adequate relief of obstruction.

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REFERENCES

- 1 von Mikulicz, J. Zur Pathologie und Therapie des Cardiospasmus, *Deutsche med Wchnschr* 30 17 19, 50 54, 1904
- 2 Heller, E. Estramukose Cardioplastik beim chronischen Cardiospasmus mit Dilatation des Oesophagus, *Mitt u d Grenzgeb d Med u Chir* 27 141 149, 1914
- 3 Wendel, W. Zur Chirurgie d Oesophagus, *Arch f klin Chir* 93 311 329, 1910
- 4 Heyrovsky, H. Casuistik und Therapie der idiopathischen Dilatation der Speiseröhre, Oesophagogastronastomose, *Arch f klin Chir* 100 703 715, 1913
- 5 Lambert, A. V. S. Treatment of Diffuse Dilatation of Oesophagus by Operation, *Surg, Gynec & Obst* 18 19, 1914
- 6 Grondahl, N. B. Cardioplastik ved Cardiospasmus, *Nord med Ark* 49 236, 1916
- 7 Finney, T. M. T. A New Method of Pyloroplasty, *Bull Johns Hopkins Hosp* 13 155 161, 1902
- 8 Bull, P. N. So Called Idiopathic Dilatation of the Oesophagus, *Ann Surg* 81 59 93, 470-493, 1925
- 9 Womack, N. A. Esophagoplasty for Esophageal Achalasia, *S Clin North America* 18 1241 1255, 1938
- 10 Ochsner, A., and DeBakey, M. Surgical Considerations of Achalasia, *Arch Surg* 41 1146 1183, 1940
- 11 Ochsner, A., and DeBakey, M. The Surgical Treatment of Achalasia of the Esophagus, *Surg, Gynec & Obst* 72 290 297, 1941
- 12 Gray, H. K., and Skinner, I. C. The Operative Treatment of Cardiospasm, *J Thoracic Surg* 10 220 243, 1940
- 13 Scott, W. I. M. Idiopathic Dilatation of the Esophagus, *Ann Surg* 122 582 605, 1945
- 14 Clagett, O. T., Moersch, H. J., and Fischer, A. Esophagogastrostomy in the Treatment of Cardiospasm, *Surg, Gynec & Obst* 81 440 445, 1945
- 15 Grimson, K. S. Total Thoracic and Partial to Total Lumbar Sympathectomy and Celiac Ganglionectomy in the Treatment of Hypertension, *Ann Surg* 114 753 775, 1941
- 16 Templeton, F. E. X-ray Examination of the Stomach, Cardiospasm, Chicago, 1944, University of Chicago Press, pp 443 453
- 17 Dragstedt, L. R., and Schafer, P. W. Removal of the Vagus Innervation of the Stomach in Gastroduodenal Ulcer, *SURGERY* 17 742 749, 1945
- 18 Sturtevant, M. Cardiospasm, *Arch Int Med* 51 714 736, 1933
- 19 Walton, A. J. Surgical Treatment of Cardiospasm, *Brit J Surg* 12 701 737, 1925
- 20 Lendrum, F. C. Anatomic Features of Cardia Orifice of the Stomach, *Arch Int Med* 59 474 511, 1937
- 21 Plummer, H. S. Diffuse Dilatation of the Esophagus Without Anatomic Stenosis (Cardiospasm), *J A M A* 58 2013 2015, 1912
- 22 Meltzer, S. G. Ein Fall von Dysphagie Nebst Bemerkungen, *Berl klin Wchnschr* 25 140 143, 1888
- 23 Rieder, W. Der sogenannte Cardiospasmus, *Deutsche Ztschr f Chir* 217 334 358, 1929
- 24 Knight, G. C. The Relation of the Extrinsic Nerves to the Functional Activity of Esophagus, *Brit J Surg* 22 155 168, 1934
- 25 Knight, G. C., and Adamson, W. A. D. Achalasia of the Cardia, *Proc Roy Soc Med* 28 891 897, 1935
- 26 Ferguson, J. H. Effects of Vagotomy on the Gastric Function of Monkeys, *Surg, Gynec & Obst* 62 689 700, 1936
- 27 Knight, G. C. Sympathectomy in the Treatment of Achalasia of the Cardia, *Brit J Surg* 22 864 876, 1935
- 28 Scott, M. W. J., and Morton, J. J. Sympathetic Inhibition of the Large Intestine in Hirschsprung's Disease, *J Clin Investigation* 9 247 262, 1930
- 29 Telford, E. D., and Simmons, H. T. Treatment of Gastrointestinal Achalasia by Spinal Anesthesia, *Brit M J* 2 1224 1226, 1939
- 30 Jackson, C. The Diaphragmatic Pinchcock in So called "Cardiospasm," *Laryngoscope* 32 139 142, 1922
- 31 Hurst, A. F. Some Disorders of the Esophagus, *J A. M. A* 102 582 587, 1934
- 32 Rake, G. W. On the Pathology of Achalasia of the Cardia, *Guy's Hosp Rep* 77 141 150, 1927

THE TREATMENT OF CARDIOSPASM BY ESOPHAGOGASTROSTOMY

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CARDIOSPASM is the term most frequently used to describe the syndrome in those patients who have more or less characteristic symptoms of dysphagia, regurgitation, and epigastric pain of long duration. The entity is not new, such cases having been reported as early as 1674, and the number recorded now exceeds 1,200. These cases are reported under many different designations, such as achalasia of the cardia, simple ectasia of the esophagus, paralytic dilatation of the esophagus, mega-esophagus, idiopathic dilatation of the esophagus, etc.

The etiology of cardiospasm is still in dispute. Some of the conditions to which it is attributed are primary apnea of the musculature of the esophagus, spasm of the cardia, failure of proper relaxation of the cardiac sphincter, spasm of the diaphragm, kinking of the esophagus, fibrosis of the periesophageal connective tissue, and autonomic imbalance.

Comparatively few cases have been reported in which operation has been performed in the attempt to relieve the condition. In 1930, Haggstrom¹ reported twenty-nine cases from the literature and added two of his own, making a total of thirty-one cases in which esophagogastrostomy was done by the transabdominal approach. No deaths occurred. At the same time he reported five cases in which operation was done by Sauerbruch by the transpleural route, with two deaths. Ochsner and DeBakey,² in 1940, reviewed the literature, collecting eighty-eight cases, and reported two of their own, in which esophagogastrostomy was done, bringing the total to ninety. In this group there were five deaths, or 6.6 per cent, and only one case in which the results were poor. These authors divided the operative procedures into four large groups depending upon whether they were directed at (1) the dilated esophagus, (2) the cardia, (3) the diaphragm, or (4) the nerve supply. Since their report there have been several other case reports in series of one to four. Clagett and associates³ in 1945 reported four cases with good results.

Dilatation is the simplest procedure and should always be given a trial. Of all the different operative procedures which have been resorted to, esophagogastrostomy, first performed by Heyrovsky⁴ in 1912, seems to us the most logical. The operation used by Heyrovsky was modified by Grondahl⁵ so that the technique is essentially the same as that used in Finney's gastroduodenostomy,⁶ applied to esophagogastrostomy. We have operated on ten patients with cardiospasm by this technique (Figs 1 to 5). In nine cases the transabdominal approach was used, while the transpleural route was utilized once (Table I).

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TABLE I. RECORD OF TEN PATIENTS TREATED BY ESOPHAGOGASTROSTOMY

CASE	AGE (YR)	SEX	LENGTH OF HISTORY (YR)	OPERATION	WEIGHT (LB)	RESULT	FOLLOW UP	
							YR	WEIGHT (LB)
1	21	F	10	Esophagogastrostomy	85	Excellent	2	128
2	36	F	10	Esophagogastrostomy	68	Excellent	2	118
3	54	F	12	Esophagogastrostomy	?	Excellent	1½	(Died of carcinoma of cervix) 150
4	35	M	4	Esophagogastrostomy	136	Excellent	2	
5	74	F	2	Esophagogastrostomy	106	Excellent	1½	125
6*	53	M	4	Esophagogastrostomy	114	Fair	1½	124
7*	61	F	2	Esophagogastrostomy	116	Fair	1½	120
8†	37	F	2½	Esophagogastrostomy	130	Excellent	4½	190
9	56	M	14	Esophagogastrostomy	160	Excellent	1½	180
10	27	F	1	Esophagogastrostomy	104	Excellent	Operation Dec 31, 1945, no follow up	

*Reoperated upon (see Fig 6)

†Operation by transthoracic route, all others done through the abdominal approach

CASE REPORTS

CASE 1—M B, a white woman, 21 years of age, entered the hospital on Dec 14, 1943, because of dysphagia, loss of weight, weakness, fainting, and dysmenorrhea. She had had dysphagia since the age of 11 years, which had become much worse during the past years. General physical examination at this time was essentially negative. Hemoglobin was 86 per cent and the red count 4,330,000. The total protein in the blood was 6.37 mg per 100 cc of blood, the albumin 4.34, and the globulin 2.03. The blood Wassermann test and urinalysis were negative. X-ray studies showed a tortuous esophagus, greatly dilated, containing much retained food and fluid (see Fig 7, A and B). Esophagoscopy on December 15 showed the esophagus to be ballooned out into a huge thin-walled structure, containing 2,000 cc of semi-digested food and debris. The esophageal wall was so thin that the right side of the heart could be seen, permitting observation of rhythmic or individual movements of the ventricle and the auricle. A No 16 bougie passed through the cardiac orifice into the stomach without difficulty. There was no evidence of ulcer or tumor. The patient was placed on a clear liquid diet, was taught how to wash out the esophagus, and was discharged, to return to the hospital on Jan 10, 1944, for operation. The general physical examination then was essentially the same as at the previous entrance. Esophagogastrostomy was done Jan 13, 1944, through a transabdominal approach and a small piece of the cardiac ring was removed for study. The pathologist reported hyperplastic esophageal and atrophic gastric mucosa. This patient developed a slight wound infection and a pelvic abscess which was drained through the cul de sac. For the first five days she received nothing by mouth. By Feb 6, 1944, when she was discharged, she was able to take a soft diet without difficulty. Her only comment was that she could feel the food go through the esophagus, drop directly into the stomach, and hit the posterior wall. She gained in weight, from 85 to 128 pounds. Since then she has gone through a normal pregnancy without difficulty. Roentgenograms taken in December, 1945, showed the esophagus still large, but no delay in emptying.



Fig 1—Exposure and freeing of lower end of esophagus.

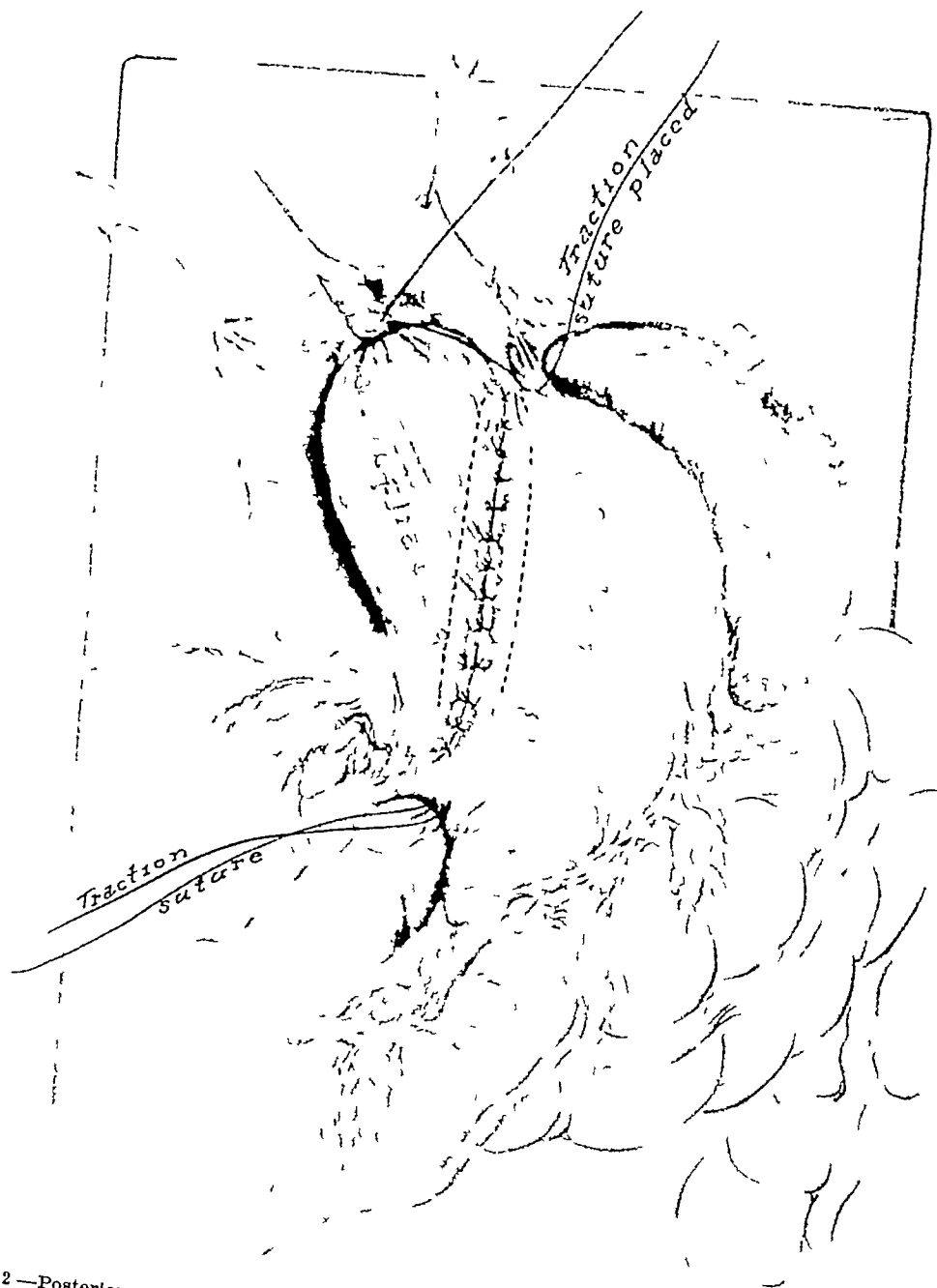


Fig 2 —Posterior row of interrupted cotton sutures laid and tied control of esophagus by cotton tape

CASE 2—F T, a Mexican woman, 36 years of age, had had bouts of vomiting after taking food, either solid or liquid, for the past ten years. Thus might occur immediately or one and one half hours after taking food. There was no blood in the vomitus. She had some slight epigastric pain radiating through to the back, which had become much worse during the last six months. Her normal weight of about 100 pounds had dropped to 68 pounds. She entered the hospital on Dec 28, 1943, and was discharged on Jan 30, 1944. General physical examination showed a markedly cachectic young woman. Blood pressure was 110/70, the hemoglobin was 95 per cent, red count 3,830,000, and white count 4,350. The urinalysis was essentially negative except for from 10 to 15 white blood cells and some bacteria. The phenol sulfonphthalein test was 72 per cent. The total blood protein was 5.95 mg per 100 c.c. of blood, the albumin 2.79, and the globulin 3.16. The blood Wassermann test was negative. The x ray studies and an esophagoscopy showed a hugely dilated esophagus filled with debris and fluid (see Fig 8, A and B). Several transfusions of blood were given and an esophagoga-

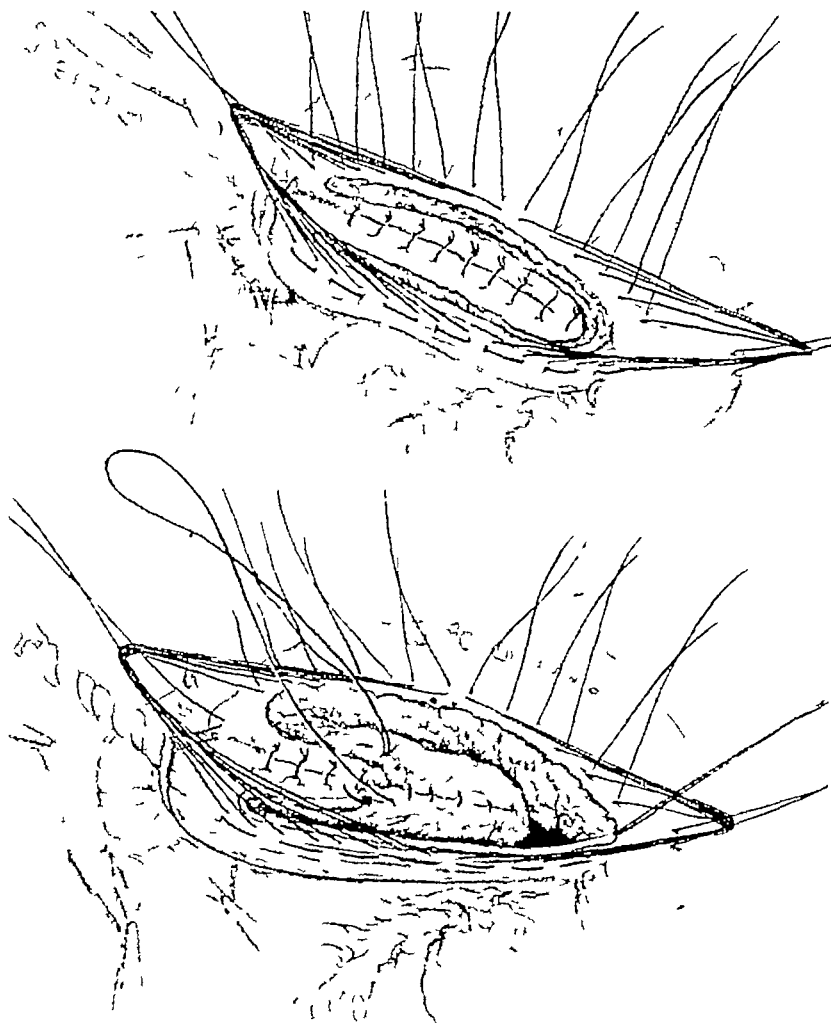


Fig 3—Posterior sutures tied. Anterior mattress sutures laid and retracted over traction sutures. Opening made in stomach and esophagus through the cardiac ring. Upper traction suture through stomach and cotton tape. Second posterior row of continuous 0000 chromic catgut sutures being placed.

trostomy was performed on Jan 15, 1944. The course was uneventful after operation. The patient was pregnant at the time and subsequently had a full term delivery of a normal child. Her weight increased to 118 pounds.

This patient reentered the hospital on Dec 11, 1944, because of some epigastric distress, weakness, and marked secondary anemia apparently resulting from a duodenal ulcer or ulcer at the anastomosis. X-ray studies showed the esophagus still to be somewhat dilated, but much smaller than it was at the time of the examination before operation. The barium went through without difficulty. The hemoglobin was built up from 28 to 75 per cent on discharge.

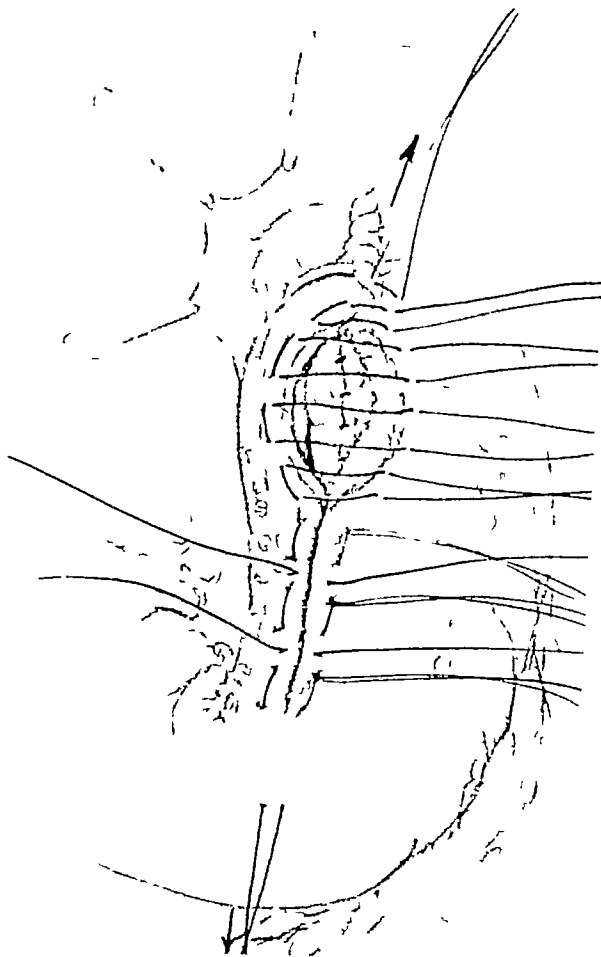


Fig 4—Anterior sutures being tied interrupted Lembert sutures between each mattress

CASE 3—A S, a white woman, 54 years of age, entered the hospital on April 27, 1944, because of vomiting for three weeks. History showed that she had had episodes of vomiting for twelve years, the attacks usually occurring immediately after breakfast. She always had some difficulty in swallowing. X-ray studies and esophagoscopy showed a markedly dilated esophagus filled with liquid and food. Examination of the blood showed the hemoglobin to be 92 per cent, the red count 4,800,000, and the white count 6,650. Urinalysis and the blood Wassermann test were negative. An esophagogastrostomy was done on May 20, 1944. Since operation the patient has been well except when she becomes upset. At such times she forces herself to vomit. She is under observation for a pelvic condition unrelated to the chief com

plaint and, at the time of her last entry, she complained that she vomited everything and was unable to swallow food, yet it was noted that she ate heartily, even asking for three extra helpings, and that she retained the food well except when members of her family were present. X ray studies showed the esophagus to be somewhat dilated, although not so much so as before operation, and the barium went through without delay.



Fig 5—Completed operation, esophagus being fastened to the diaphragm

CASE 4—J M L., a white man, 35 years of age, entered the hospital on March 30, 1944, and was discharged on April 17, 1944. His chief complaint was that, since the fall of 1941, he vomited whenever he drank beer or carbonated water. This started at the time he was obtaining a divorce. The vomiting occurred at no other time. It was associated with pain high in the epigastrium. The symptoms of regurgitation and vomiting became much worse during the period in which he was obtaining a divorce. In 1942 he joined the Navy and worked very long and arduous hours. He would awaken at night to find regurgitated food on his pillow. On several occasions he was in Naval hospitals, where a dilated esophagus was demonstrated by x ray examinations and esophagoscopies. Antispasmodics were administered and dilatation was done. He was finally discharged from the Navy in August, 1943. His weight had dropped from 155 to 136 pounds. After discharge from the Navy the vomiting and dysphagia increased. X ray studies showed that about 50 per cent of the barium remained in the esophagus after six hours. The lower end of the esophagus came to a very fine point. The general physical examination on entry was entirely negative. Examination of the blood showed 94 per cent

hemoglobin with a red cell count of 4,790,000 and a white count of 5,200, the protein content was 5.59 mg per 100 cc of blood, the albumin 3.98, and the globulin 1.61. The blood Wassermann test was negative. An esophagogastrostomy was done on April 6, 1944. The postoperative course was entirely uneventful and he was discharged twelve days after operation. His present weight is 150 pounds. He holds a very responsible position, can eat anything, and has had no more vomiting.

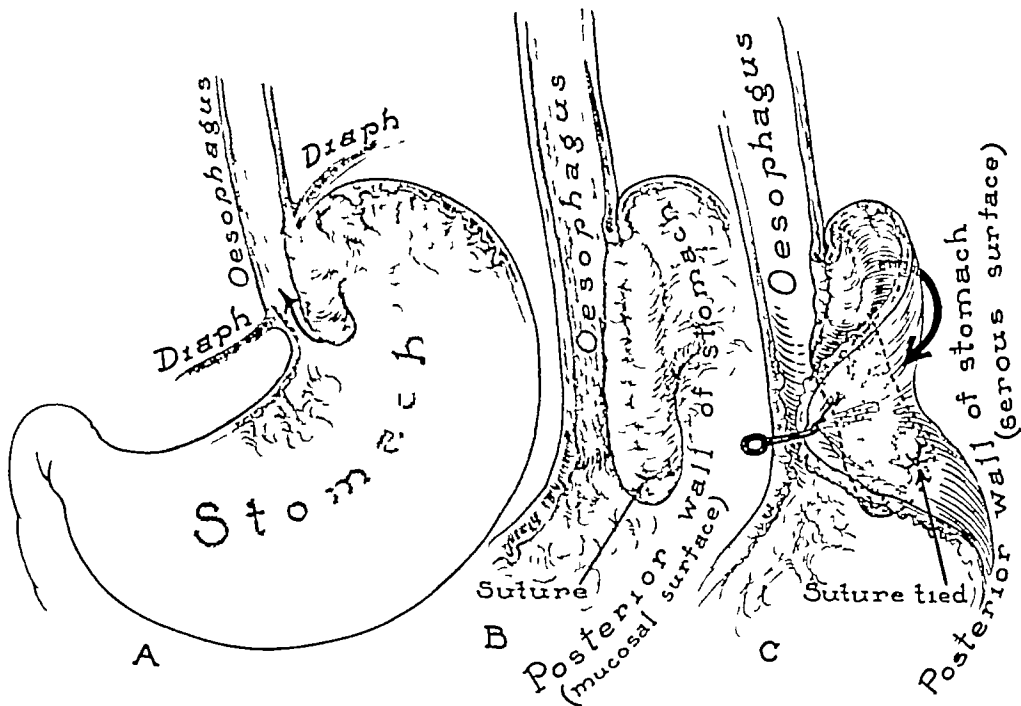


Fig 6—Showing flaplike valve action of posterior wall in two patients and method of correcting it. One suture placed through the flap and through the stomach wall and tied on the posterior wall.

CASE 5—D S, a white woman, 74 years of age, entered the hospital on Oct 5, 1944, and was discharged on Oct 24, 1944. The chief complaint was that for two years she had had difficulty in retaining food. At first she had trouble only with solids, then with soft foods, and finally with liquids. She had lost fifty pounds in weight. No pain was associated with swallowing. This patient had been studied elsewhere and an exploration of the abdomen had been done to rule out carcinoma of the cardia. She was not benefited by this operation. The hemoglobin was 74 per cent, the red count 4,000,000, and the white count 8,600, urinalysis was negative. The blood pressure was 170/80. X-ray study and esophagoscopy showed a widely dilated and tortuous esophagus. Esophagogastrostomy was done on Oct 10, 1944. The postoperative course was uneventful and she was discharged on the fourteenth postoperative day. Microscopic study of the tissue removed from the cardiac ring showed a chronic inflammation and fibrosis. This patient has done very well since operation and has gained twelve pounds in weight. She has had no vomiting except after some unusual mental strain such as an argument with friends or relatives. Occasionally she has regurgitation if she stoops over quickly soon after a meal.

CASE 6—G R, a white man, 53 years of age, entered the hospital on Sept 24, 1944, and was discharged on Oct 14, 1944. He had had difficulty in swallowing for four years and recently had become worse so that he began to lose weight. He had no real dysphagia but did have to drink large quantities of water in order to be able to swallow soft food. He had had repeated dilatations and x-ray studies during the four years and antispasmodics had been

A.



B

Fig 7 (Case 1)—A Roentgenogram taken before surgery B Roentgenogram taken after surgery



Fig 8 (Case 2) —A, Roentgenogram taken before surgery B, Roentgenogram taken after surgery

tried X ray studies and an esophagoscopy showed a dilated esophagus with the sigmoid curve to the right at the lower end of the esophagus near the cardiac orifice. No ulcer or tumor was seen. He had lost ten pounds in weight but the general physical examination was otherwise negative. Blood pressure was 130/80. The Wassermann test was negative as was the urinalysis. Examination of the blood showed the hemoglobin to be 94 per cent, the red count 4,640,000 and the white count 5,400. An esophagogastrostomy was done on Oct 2, 1944. The postoperative course was uneventful but, as far as the ability to swallow was concerned, improvement was slight.

On Dec 1, 1944, he returned to the hospital and an esophagoscopy was done. There was no evidence of ulceration, but it appeared that the new opening was not as large as it should be. Also, it showed that the posterior wall of the anastomosis acted like a flapper valve. A No 16 bougie went through the orifice without difficulty. Thereafter the patient improved somewhat and regained some weight. Since the outcome could not be called satisfactory, a subsequent operative procedure to enlarge the opening was required.

Reoperation was done Jan 30, 1945, and the opening was enlarged and the posterior wall of the anastomosis which acted like a valve was fastened to the posterior wall of the stomach (Fig 6). Since then he has gained weight and has no difficulty in swallowing.

CASE 7—E M., a white woman, 61 years of age, entered the hospital on Oct 17, 1944, and was discharged on Oct 31, 1944. The complaint was of regurgitation of undigested food and liquids and some pain at the lower end of the xiphoid process. She dated the complaint from a time one and one-half years previously, when she fell, striking over the xiphoid process, and also fracturing some ribs. The vomiting gradually grew worse, particularly if she became mentally upset. Her weight dropped from 140 to 116 pounds. X ray examinations and esophagoscopy showed marked dilatation of the esophagus without evidence of ulcer or tumor. The cardia was dilated with but temporary relief. General physical examination was negative except that the blood pressure was 185/100. Examination of the blood showed the hemoglobin to be 100 per cent, the red count was 5,120,000, and the white count and differential were normal. The blood Wassermann test and urinalysis were negative. An esophagogastrostomy was performed on Oct 19, 1944. The postoperative recovery was entirely uneventful and she was discharged on the twelfth day after the operation. Microscopic examination of the tissue removed from the cardiac ring showed fibrosis and chronic inflammation, with edema. This patient did fairly well after operation but continued to have some difficulty in swallowing food, particularly following mental upset. From a surgical standpoint her condition was not entirely satisfactory.

The patient re-entered the hospital April 19, 1945, for reoperation. At operation the posterior wall of the anastomosis was found to be acting like a valve. It was sutured back to the posterior wall (see Fig 6). Since then she has gained weight.

CASE 8—M L., a white woman, 37 years of age, entered the hospital on Nov 29, 1941, and was discharged on Dec 24, 1941. For the last two and one-half years she had vomited almost every day, particularly after taking water. She had a sense of fullness at the base of the esophagus directly over the xiphoid. She had lost some weight and suffered paroxysms of vomiting. In December, 1939, x ray studies and esophagoscopy had shown a dilated esophagus. A general physical examination was essentially negative. The cardiac end of the esophagus was dilated on nine occasions, on the last of which a perforation at the lower end of the esophagus was caused. An emergency operation was performed, through a transthoracic approach, and an esophagogastrostomy was done on Nov 29, 1941. The postoperative recovery was very good. In December, 1944, she reported that she was able to swallow perfectly, but had had recurrent attacks of biliousness caused by disease of the gall bladder. Apparently this illness had no connection with the operation on the esophagus.

CASE 9—H G W., a white man, 65 years of age, entered the hospital Dec 11, 1944, and was discharged Dec 27, 1944. The chief complaint was that he was unable to eat any solid food for the last three months. He had lost ten pounds in weight.

Past history revealed that he had been in this hospital in October, 1935, because of regurgitation of food recently eaten which had been going on for four years before that. The vomitus and regurgitation consisted of unchanged and undigested food. At times he would vomit food eaten twenty-four to forty-eight hours before. His weight dropped from 154 to 120 pounds. This episode of vomiting and regurgitation came on very shortly following the rather sudden death of his employer of whom he was very fond. He noticed recurrence of severe attacks of vomiting when under an undue amount of emotional strain.

General physical examination at this entry was essentially negative. All the laboratory work was entirely within normal limits and the only positive findings were the x-ray findings of the esophagus. X-ray examination of the esophagus showed it to be a large, easily dilatable tube with very active peristalsis. At the lower end, just above the diaphragm, there was a marked, funnel-shaped narrowing of the esophagus.

An esophagogastrostomy was done Dec. 15, 1944. A biopsy of the cardiac ring was taken, and the pathologic report revealed tissue from the esophagus showing chronic inflammation and fibrosis. The postoperative course was essentially uneventful. He was discharged from the hospital twelve days postoperatively, taking a soft diet without difficulty.

CASE 10—R. R., a colored woman 27 years of age entered the hospital Dec. 22, 1945 because of loss of weight, weakness and vomiting after eating. This difficulty had been present for at least eleven months and had become severe during the past six months. Her weight one year before was 176 pounds and at the time of admission was 104. She thought the vomiting began after she had taken some pills prescribed for her by a chiropractor to bring on menstruation. After taking the pills for two days, a "blob of stuff" was ejected just like a miscarriage and bleeding continued, off and on, for three weeks. She complained that the pills made her throat burn and contract down so that food would not go through. Following this, the burning sensation continued and she consulted a doctor who took roentgenograms and found a markedly dilated esophagus with a very narrow opening into the cardiac end of the stomach. These findings were confirmed at this hospital. She was found to have a 4 plus Wassermann reaction and she was put on an intensive course of antisyphilitic therapy. During this time, however, there was no change in the ability for her to keep food down. The general physical examination upon entrance into the hospital was essentially negative, except for evidence of weight loss. Blood pressure was 120/80, hemoglobin 92 per cent, red count 4,310,000, white count 7,200, with a normal differential. The urine was negative. Due to an extremely sensitive gag reflex and lack of cooperation of the patient, dilatation was not satisfactory. She was prepared in the hospital by washing the esophagus out twice a day for five days. Some of the material returned was very foul smelling. An esophagogastrostomy was done on Dec. 31, 1945. The postoperative course was very smooth. It is too short a time to give any particular follow-up on this patient.

DISCUSSION

Certain characteristics are evident in all of these cases. For example, the patient's symptoms become pronounced when he is under mental or emotional strain. When all facts are considered, it seems evident that some neurogenic factor enters into the etiology of the condition. This is especially evident in Cases 3, 4, 5, 7, and 8.

The ages varied widely, indicating that cardiospasm may be found at almost any age. In the small number of cases reported, the disease was more common in women than in men.

The results of esophagogastrostomy have proved so satisfactory in the ten patients treated by this method that the performance of the operation is felt to be justified. There were no deaths in this series, and eight patients received complete relief, two patients required a subsequent operation. Esophago-

gastrostomy appears to offer a more direct approach to the problem than any other of the numerous operations suggested. The details of the operation have been so well described by Ochsner and DeBakey² that further report other than the illustrations seemed unnecessary.

ADDENDUM

Dr Clayton Lyons of our Staff has recently operated upon a sailor for severe cardiospasm through the transthoracic route with excellent results. This patient had had two previous procedures done through the abdomen for dilatation of the cardia without benefit.

REFERENCES

- 1 Haggstrom, P. Zwei Fälle von Kardiospasmus und Ösophagusdilatation, die mit glücklichen Ausgang nach Heyrovsky operiert wurden, *Acta chir Scandinav* 66 345, 1930
- 2 Ochsner, Alton, and DeBakey, Michael. Surgical Considerations of Achalasia, a Review of the Literature and Report of Three Cases, *Arch Surg* 41 1146 1183, 1940
- 3 Clagett, O. Theron, Moersch, Herman J., and Fischer, Albert. Esophagogastrostomy in the Treatment of Cardiospasm, *Surg, Gynec & Obst* 81 440 445, 1945
- 4 Heyrovsky, H. Cited by Ochsner and DeBakey²
- 5 Grondahl, N. B. Cited by Ochsner and DeBakey²
- 6 Finney, John M. T. A New Method of Pyloroplasty, *Johns Hopkins Hosp Bull* 13 155 161, 1902

TRANSPLANTATION OF TOES FOR FINGERS

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Strong Memorial Hospital)*

THE purpose of this report is to consider the transplantation of toes as a means of repairing losses of fingers. The indications for replacing partially or completely lost fingers is for the most part cosmetic although to a certain extent utilitarian. One can get along well with three or even two fingers as long as the thumb is intact. However, a lost thumb constitutes a great disability and when possible some substitute should be furnished. For this reason most reported reconstructions of lost digits of the hand have been restorations, by one means or another, of the thumb. There are numerous methods which have been used more or less successfully. Among these are prosthesis, phalangization, rotary angulatory osteotomy, tubular pedicled graft with inserted bone graft, transplantation of index finger to position of thumb, and digital transplantation from either the hand or the foot. We will not discuss, in this report, the merits or objections to the various methods used in thumb restoration.

If one wishes to replace a lost finger, only a few of these are applicable. Prosthesis is mentioned only to be discarded. While a prosthesis may perform a fair cosmetic function if carefully made and colored, it is insensitive, troublesome to keep on, and is usually soon given up by the wearer. A finger can be elongated to normal by a tubed graft of skin and subcutaneous tissue into which a bone graft is later inserted and fixed to the metacarpal or the most distal phalanx present. Such a substitute fails cosmetically since the skin is neither the same color nor texture, and does not have a nail. The transplantation of a toe comes closest to fulfilling requirements of appearance and function.

The substitution of toes for fingers was first conceived by Nicoladoni¹. He reported, in 1900, the substitution of a part of the second toe for a partial defect of the thumb. The method has become known as the Nicoladoni procedure, although Von Eiselsberg² in the same year reported the transplantation of the second toe to replace an almost complete loss of the index finger.

Since then there have been scattered reports on the subject. In 1930 Gueullette⁴ collected 20 cases of reconstruction of the thumb by digital transplantation. He found 12 cases in which the great toe had been used, 5 in which the second toe was used, and 3 in which a finger had been transplanted. Of these 20 cases, 7 had active movement and there were only 3 which he classified as perfect.

Bunnell,¹⁰ in discussing the subject of reconstruction of the thumb, more or less condemned digital transplantation. He stated, "The transplanted digit undergoes atrophy as in a paralytic finger or one with a girdling scar, all its

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tissues suffering. Sensation is very poor, as no one as yet has reported reconnecting the nerves. Trophic sores and deep, progressing ulceration have occurred. In most cases the new digit is hooked, atrophic, stiff, and without motion." By inference one is led to believe that he favors other methods of reconstructing the thumb.

However, from the more recent literature one is not inclined to look upon the matter in quite such a pessimistic light. There are some results which have been examined and reported years afterward which appear to have been quite worth while and most of the poor ones can, I believe, be attributed to technical difficulties or to poorly conceived substitutes.

For example, Oehlecker¹¹ reported a twenty-year follow-up on a case in which the great toe was transplanted to replace a left thumb lost at the metacarpophalangeal joint. The patient was a chemistry professor, was able to hold test tubes, beakers, etc., with the thumb and index finger, played the violin, and was completely satisfied with the digit.

Ranschburg¹⁶ reported the neurologic findings twenty years after Esser had transplanted part of the metacarpals and four small toes to a hand on which only the thumb was present. In this case the tendons had been united. The man was able to flex the toes and hand in mass to oppose the thumb. The neurologic findings twenty years later were most interesting. Light touch was excellent. Localization of touch on the volar surface was good, the man being able to localize which finger-toe was touched, but on the dorsum knew only that the dorsum rather than the volar surface was stroked. He could localize pain stimuli correctly. Temperature sense on the transplanted foot-hand was far more accurate than on the normal foot. There were four to five times as many false answers to temperature tests on the normal foot as on the transplanted one. This man was able to use the hand in farm work and got along satisfactorily.

A somewhat less satisfactory result was reported by Neuhoef¹⁸. The difficulty in this case which was reported seventeen years after the transplantation can be attributed, I believe, to the fact that a toe cannot be expected to grow to the size of a finger, this illustrates that some cases classified as unsatisfactory are due to errors in the original conception of the substitution. When the patient was 7 years of age, the second toe was substituted for a complete congenital absence of a middle finger. The toe slowly increased in length and thickness until adult life, but remained more nearly the length of a toe than a finger. Neuhoef stated that sensation returned in ringlike fashion and was "normal" in about six months.

During the past ten years we have found twelve reports on this subject. It is interesting to note that six of these have come from Soviet Russia where the operation seems to have been more used than elsewhere. For the most part these transplantations have been successfully accomplished and the ultimate result has been worth while.

From the literature one gains the impression that for losses of the thumb from the metacarpophalangeal joint distally, transplantation of the great toe

on the *opposite* side is the best digit for substitution. This is so because the position of the hand on the opposite foot is a natural one that can be maintained without strain. Finger reconstructions should be limited to losses which are such that the transplanted toe can restore normal length. The best digit for substitution is the second toe on the same side. One further notes that the almost sole cause of failure is the inability of the patient to bear the irksome position for the necessary period of three to four weeks. If the pedicle is divided too soon, the toe is lost completely or has a period of poor circulation which later predisposes to atrophic changes and scarring. It is also evident from the various reports that, even though the tendons be united, active motion is not assured. However, in practically all instances fair sensation returns in ring-like fashion from the anastomosis to the distal tip. The return of touch pain, and temperature is constant. Localization of touch is fair but astereognosis is the rule.

OPERATIVE PROCEDURE

The operation reported in most instances varies little from the original Nicoladoni procedure. The details may differ depending upon the level of the finger loss.

A U-shaped skin flap is turned distally at the base of the second toe and both dorsal arteries are divided. The extensor tendon of the toe is cut high, the periosteum reflected as a cuff, and the bone divided. A transverse incision is made across the stump of the finger, the extensor tendon located, the periosteum reflected from the bone, and the bone end freshened. The distal end of the sectioned bone of the toe is dislocated and the bone of the finger and toe approximated by suturing the reflected periosteal cuffs. The extensor tendons are sutured so that the suture line is proximal to the periosteal closure. The skin flap is sutured to the skin of the finger and a plaster cast applied. In about one month the volar attachment is divided and the flexor tendons are sutured.

In the case to be reported, the operation was modified in two respects. First, the incision on the toe was made longitudinally down to the extensor tendon and the tendon sectioned. Thus, the entire arterial supply of the toe was preserved. Second, since the distal two phalanges of the second toe corresponded exactly in length to the amount of finger lost, the proximal phalanx was dissected out subperiosteally and removed, leaving the joint capsule of the proximal interphalangeal joint attached to the proximal end of the second phalanx. The flexor tendon of the toe was then severed. A dorsal triangular shaped skin flap was raised from the stump of the finger. The capsular periosteal structures were elevated as a cuff from the phalanx and the extensor and flexor tendons isolated. The end of the phalanx, which was covered by fibrous tissue, was then inserted into the trough made by removal of the proximal toe phalanx, and the joint surfaces approximated by suturing the reflected capsular cuffs and the flexor and extensor tendons. The triangular finger flap of skin was sutured to the edges of the longitudinal incision on the dorsum of the toe. The necessary position had gradually been gained prior to operation, and

all that remained to be done was immobilization of the arm to the flexed lower extremity. The details of the case are as follows:

CASE REPORT

G. M. (S. M. H. No. 227476), a 26 year old, single white woman, a stenographer, was first seen Jan. 17, 1945, because of a partial amputation of the left index finger. On Dec. 12, 1944, she was attempting to disengage the locked bumpers of two cars. The driver of one car was her sister, who inadvertently put the car in gear, catching the patient's left index finger between the bumpers. The finger was amputated at the mid portion of the middle phalanx. When seen six weeks later the stump was well healed (Fig. 1). There was considerable anxiety on the part of the sister, who felt responsible and wished everything possible done to repair the damage. They were advised that a toe transplant could be done after the injured finger had returned to a more normal state.

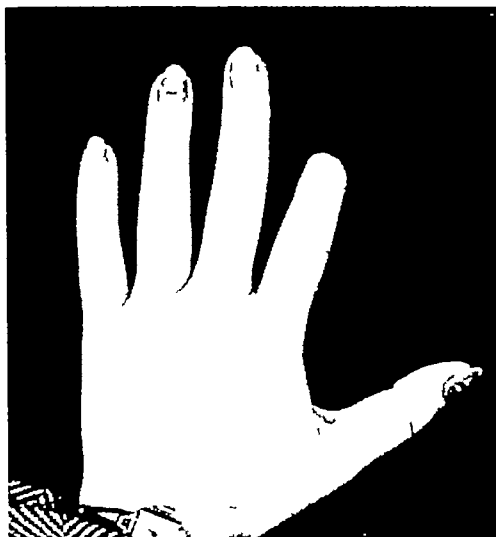


Fig. 1—Loss of index finger just proximal to the distal phalangeal joint.

The patient was admitted to the Strong Memorial Hospital on April 25, 1945. On April 28 the left knee was immobilized in acute flexion in a plaster cast. The circulation of the foot remained satisfactory and four days later a body cast was applied to hold the left hip in acute flexion. The patient tolerated the position well and four days later, on May 5, 1945, the stump of the left index finger was attached to the left second toe as described (Fig. 2). The side of the cast was padded with felt and the arm was immobilized against it with elastic adhesive. The wound healed cleanly. The circulation of the toe remained completely normal. The patient tolerated the position exceedingly well. On May 27, 1945, twenty-two days later, the toe pedicle was divided from midline dorsally to midline volarly, vessels were ligated, and the wound was sutured. The circulation remained completely normal. On June 5, 1945, exactly one month after attachment, the pedicle was completely severed. No attempt was made to suture the wound as it was feared this might compromise the blood supply. The wound smoothed out spontaneously and quickly healed. The patient was discharged from the hospital on June 14, 1945. On Oct. 8, 1945, she was readmitted to the hospital and the excess soft tissue at the junction trimmed out on one side (Fig. 3). It is planned to do this on the remaining side, but since the patient married and became pregnant, this has been delayed. She was last seen on Jan. 26, 1946, about eight months after completion of the transplant and only about three and one-half months since the trimming operation. The finger is normal color and the nail has already become more fingerlike. There is no active

motion of the distal phalangeal joint (Fig 4) Sensation has returned to the level of the nail bed She is able to localize light touch and pinprick correctly over this area and to differentiate hot and cold

A

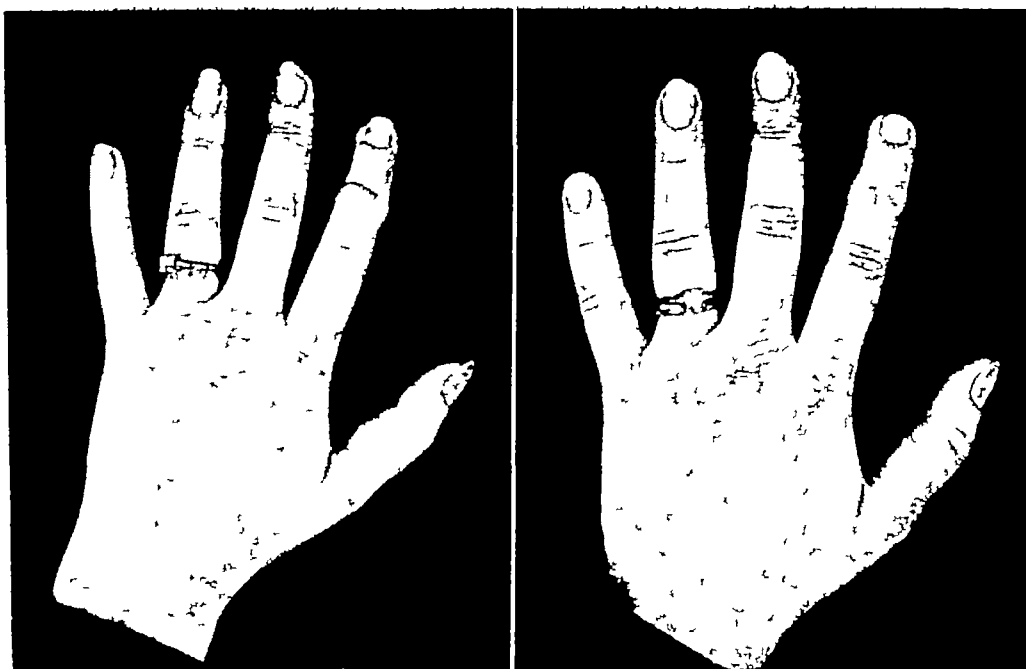


B

FIG. 2—A. This position was obtained gradually. The knee was first immobilized in acute flexion and after four days the trunk was encased in plaster and attached to the leg cast to hold the hip acutely flexed. If the patient tolerates these steps preoperatively, the chances of maintaining the position for the necessary four weeks are good. B, The circulation of the toe remained normal and the finger and toe healed together cleanly.

SUMMARY

The transplantation of a toe to replace a missing digit of the hand was first reported by Nicoladoni in 1900. There are now a few cases in the literature which have been followed for as long as twenty years. From these reports it



A

B

Fig 3—A, The soft tissues are redundant at the line of anastomosis. B, A few months later one side of the finger has been smoothed out by excising excess skin and subcutaneous tissue. This will be repeated on the opposite side.

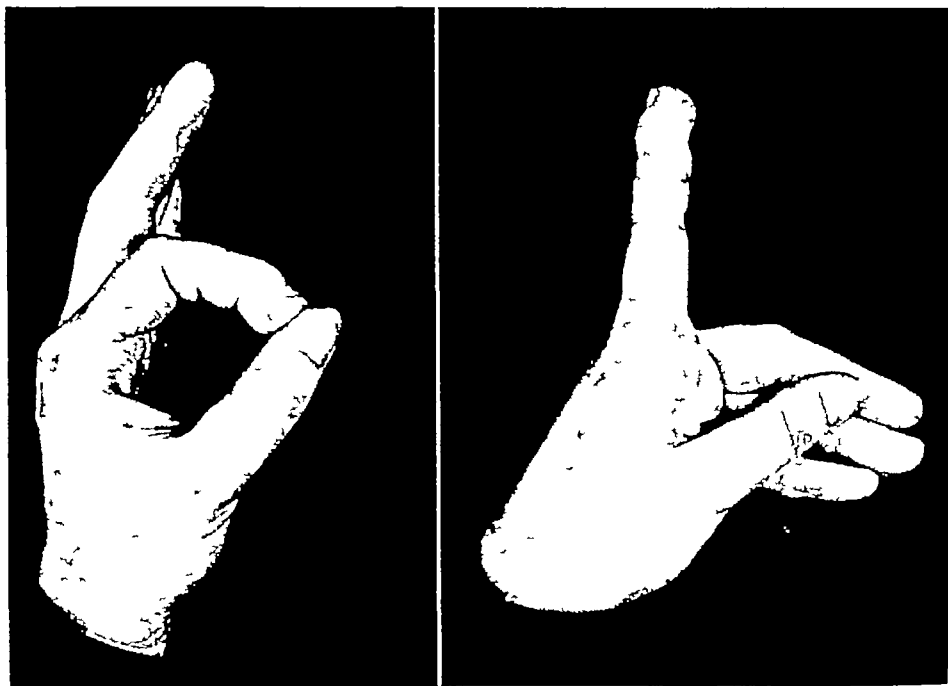


Fig 4—The finger is stable but has no active motion. Sensation has returned to the level of the nail bed. The finger can be usefully apposed to the thumb.

would seem that the ultimate result, while not perfect, is worth while. It has been found that replacement of the thumb is best done by transplanting the great toe of the opposite foot and that the second toe on the same side is most useful for finger restorations. Complete active motion of the transplanted digit is the exception rather than the rule but sensation returns over a period of months so that localization of touch, pain, and temperature is fairly normal.

The replacement of a finger with the second toe is best limited to those cases in which the loss is such that the toe transplant can restore full length.

REFERENCES

- 1 Nicoladoni, C Daumenplastik Undorganischer Ersatz der Fingerspitze, Arch f klin Chr 61 606, 1900
- 2 Von Eiselsberg, F Ersatz des Zeigefingers durch die Zweite Zehe, Arch f klin Chr 61 988, 1900
- 3 Krause, F Ersatz des Daumens Aus der Grossen Zehe, Berl klin Wchnschr 48 1527, 1906
- 4 Gueullette, R Étude Critique des Procédés de Restauration du Pouce, J de Chr 36 1, 1930
- 5 Kleinschmidt, O Zum Ersatz des Daumens Durch Die Zweite Zehe, Arch f klin Chr 164 809, 1931
- 6 Labunskaya, O V Surgical Substitution of Toes for Missing Fingers, Sovet khir 6 503, 1934.
- 7 Jiano, J Autografts of Phalanges of Toes in Reconstruction of Fingers, Rev de chir, Bucuresti 37 761, 1934
- 8 Borisov, M V Transplantation of Toes for Fingers, Sovet khir 7 136 40, 1935
- 9 Labunskaya, O V Transplantation of Toes for Fingers, Ann Surg 102 1-4, 1935
- 10 Kuslik, M. I Transplantation of Toe According to Method of Nicoladoni, Case, Arch Surg 32 123, 1936
- 11 Oehlecker, F Late Results of Transplantation of Large Toe to Replace Lost Thumb, Arch. f klin Chr 189 674 80, 1937
- 12 Azbanovskiy, V P Transplantation of Toe to Replace Thumb (Nicoladoni Method), Vestnik khir 55 626 29, 1938
- 13 Apetrovsky, K. A Plastic Reconstructions of Fingers by Means of Transplantation of Toes, Ortop i travmatol 13 74 78 1939
- 14 Novitskiy, S T Total Transplantation of Large Toe to Replace Thumb, Vestnik khir 57 352 371, 1939
- 15 Soralue, J A Transplantation of Large Toe to Replace Thumb, Semana méd españ 3 81 84, 1940
- 16 Esser, J F S, and Ranschburg, P Reconstruction of a Hand and Four Fingers by Transplantation of the Middle Part of the Foot and Four Toes, Ann Surg 111 655, 1940
- 17 Blair, V P, and Byars, L Toe to Finger Transplant, Ann Surg 112 287, 1940
- 18 Neuhof, H Transplantation of Toe for Missing Finger, End Result, Ann Surg 112 291, 1940
- 19 Bunnell, S Surgery of the Hand, Philadelphia, 1944, J B Lippincott Company

CLINICAL AND EXPERIMENTAL OBSERVATIONS ON THE USE OF GELATIN SPONGE OR FOAM

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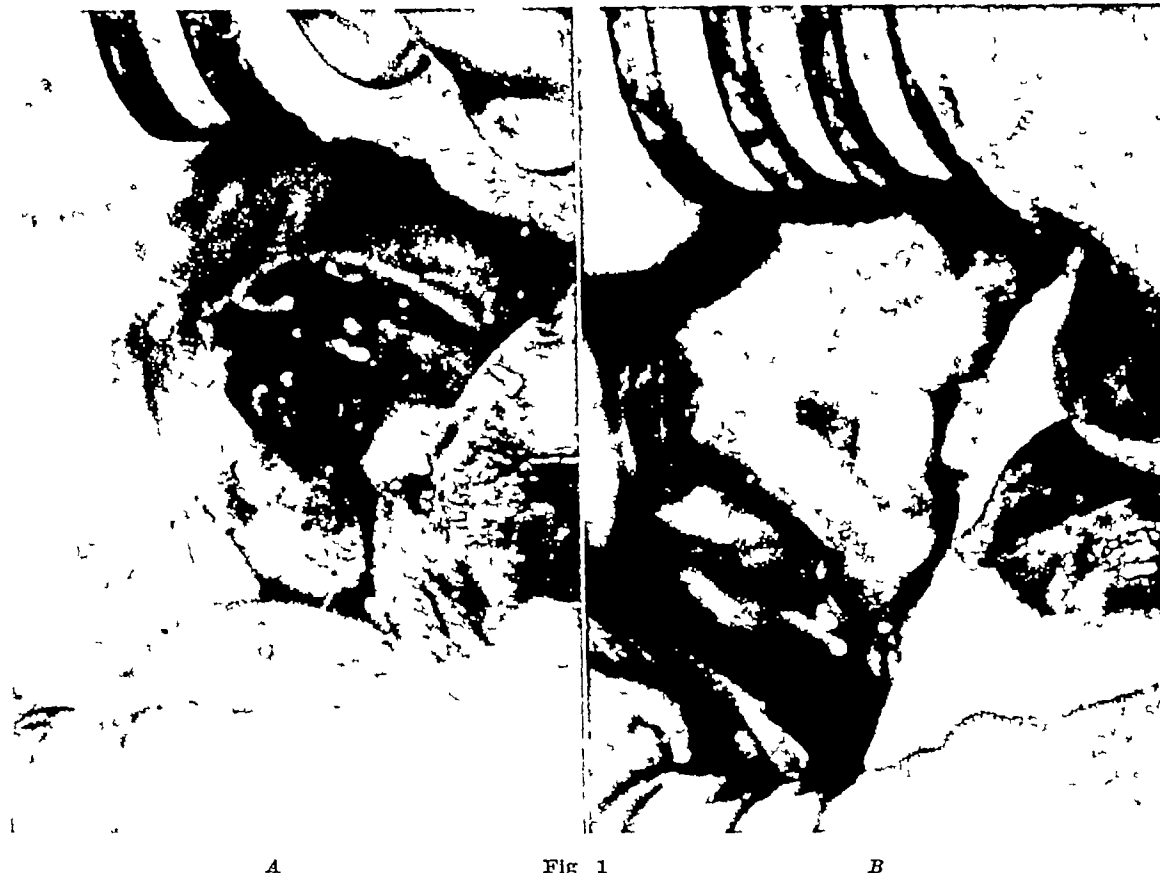
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OF THE recent advances in operative surgical technique, the development of absorbable hemostatic agents is one of the most interesting. The success of fibrin foam in neurosurgery has been made possible by the plasma fractionation program which has been conducted in the department of physical chemistry of the Harvard Medical School¹ and by the experimental and clinical work on this material by Ingraham and Bailey,² and by Woodhall.³ The usefulness of oxidized or soluble cellulose has been well presented in several reports by Frantz and co-workers,⁴ and others.⁵

A third hemostatic substance is gelatin sponge or foam. This was first described by Cornell and Wise,⁶ and subsequently has been the subject of excellent experimental and clinical evaluation in neurosurgery by Pilcher and Meacham,⁷ and by Light and Prentice.⁸ We have reported studies on the absorbability of gelatin sponge.⁹ It was found to undergo absorption within about five weeks when implanted in the liver, kidneys, spleen, omentum, or abdominal wall. In the presence of a conspicuous leucocytic reaction the absorption was considerably accelerated. The response to the gelatin sponge was generally of a nature which could be described as a nominal or minimal tissue reaction as compared with what one frequently observes with absorbable suture material. Subsequent to the absorption there was no residual inflammatory reaction observed. A limited number of clinical observations were also reported. To evaluate the usefulness of the gelatin sponge in the hemostasis problems of general surgery, further experimental and clinical studies have been conducted.

A series of thirty dogs was subjected to laparotomy using aseptic technique and ether anesthesia. Wounds of various sizes and types were made in the liver, kidneys, or spleen. The gelatin sponge was moistened in saline solution, the air removed from the sponge, and the excess saline solution expressed from the sponge. It was then applied to the bleeding wound with gentle pressure for about three minutes. The sponge became adherent to the raw surface and controlled the bleeding. In a few instances a second application was necessary. No suturing was required to supplement the hemostasis or hold the sponge in place. The size of the wounds varied from a deep scalpel incision to a moderate-sized wedge-shaped resection of a portion of a lobe of the liver (see Fig. 1). In a few instances an entire lobe was removed. One of the most

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Feb 7-9 1946



A

Fig 1

B

Fig 1—A, Wedge-shaped resection of liver tissue in experimental animal. free bleeding occurs from the raw surface. B, Gelatin sponge packed into the wound of the liver producing complete hemostasis. The sponge becomes rather firmly adherent to the raw surface of the liver. Liver tissue which has been resected is shown on gauze at lower portion of photograph.

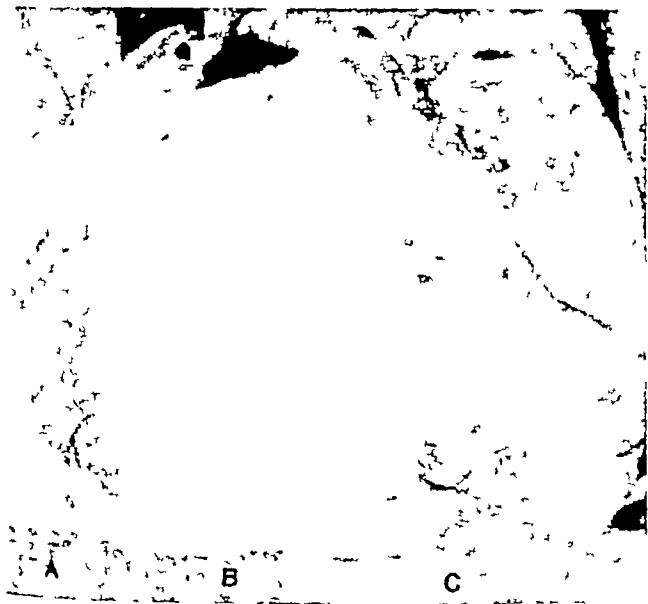


Fig 2—Gelatin sponge (A), soluble cellulose (B) and fibrin foam (C) packed into wedge-shaped wounds of liver of experimental animal. Note the black appearance of the soluble cellulose. The hemostatic action of these three materials appeared to be about the same.

Fig 2

interesting observations aside from the control of the bleeding was the manner in which the sponge became adherent to the wound. Within one-half hour it would become sufficiently adherent to the raw surface that it was often difficult to remove the sponge without tearing it.

These experiments on the hemostatic action of the gelatin sponge were done for the most part without the addition of thrombin. In such experiments as were conducted with the gelatin sponge soaked in thrombin there appeared to be a more rapid hemostatic action, although this was not outstanding as compared with the sponge alone.

Control studies were made in many of the animals using soluble cellulose. In a few animals fibrin foam was also used (see Fig 2). Thrombin was not added to either of these two hemostatic materials. The size or type of incision used in the liver, kidney, or spleen for these control studies was, of course, identical. The immediate hemostatic action of gelatin sponge, soluble cellulose, and fibrin foam appeared to be approximately the same. The soluble cellulose, which turns black upon contact with blood, did not adhere quite as firmly to the raw surface of the wound as the gelatin sponge. The fibrin foam mass could be more easily broken up than the gelatin sponge.

These animals were sacrificed at varying periods of time from one day to six months after operation. No evidence of secondary hemorrhage was found where the gelatin sponge had been used for obtaining hemostasis. In one animal, however, there was evidence that the soluble cellulose had become dislodged from a wound in the liver which led to a fatal secondary hemorrhage.

Within a few days the omentum was generally found to be adherent to the wounds packed with the hemostatic materials, thus forming a protective covering to the wound. In some instances there were adhesions to adjacent organs which were dependent to a considerable extent on the magnitude of the wound and the amount of hemostatic substance used. After about four days it was difficult to identify the soluble cellulose grossly although the gelatin sponge could generally be identified. In a few instances the gelatin sponge implanted in large wedge-shaped resections of the liver produced a small cavity within about ten days, which was walled off by adhesions to surrounding organs and the omentum, and which contained a rather gelatinous-like exudate. This undoubtedly represented the liquefaction of the gelatin sponge, since it could not be otherwise identified in the wound.

In these experiments where large wounds were made in the liver and other organs and large pieces of sponge implanted therein, it was generally found that the absorption of the gelatin sponge was more rapid than was observed in the previously reported study where relatively small incisions and small amounts of sponge were used. Microscopic studies of the tissues in this series demonstrated complete absorption of the gelatin sponge in a number of instances within two to three weeks. In the previous study there was microscopic evidence of the gelatin sponge in the liver up to thirty-four days.

A clinical evaluation of gelatin sponge has been carried out on sixty patients. In twelve cholecystectomies the sponge was used on the undersurface

of the liver to control the bleeding after removal of the gall bladder. It was necessary to hold the sponge in place with sutures in several of these. In five exploratory laparotomies at which a biopsy of the liver was taken, the sponge was packed into the bleeding wound in the liver and held in place by a few mattress sutures. In one of these cases two attempts were made to control the bleeding by packing with soluble cellulose for three minutes each. The bleeding was not controlled by the cellulose but after the application of gelatin sponge it promptly stopped. Three of these gelatin sponge implants in biopsy incisions in the liver, which were performed to establish the diagnosis of an inoperable neoplasm of the liver, were subsequently recovered at autopsy. The microscopic sections showed that the sponge was undergoing absorption in a manner similar to that which was previously described for the experimental implants in the liver (see Fig 3).



Fig 3—Photomicrograph of gelatin sponge in liver of patient seven days after exploratory laparotomy and biopsy of liver. Specimen was recovered at autopsy which demonstrated carcinomatosis and cirrhosis of liver. The interstices of the sponge are filled with red blood cells, some fibrinous exudate and a moderate number of polymorphonuclear leucocytes. There is a zone of fibrosis and cellular invasion between the liver cells and the sponge.

In a splenectomy some very troublesome bleeding occurred from the undersurface of the diaphragm to which the spleen had been adherent. This bleeding was promptly controlled by the application of several large squares of gelatin sponge. It is believed that this contributed to the recovery of the patient. In two neoplasms involving the mesentery of the small intestine a biopsy was taken and rather troublesome bleeding encountered. This was controlled by the application of gelatin sponge.

In operations on the thyroid the gelatin sponge has been used in six thyroidectomies and in one biopsy (see Fig 4). The magnitude of residual bleeding after ligation was relatively slight and ordinarily would not have required

additional ligature. Such slight oozing as was present was controlled by the sponge. In these cases there appeared to be somewhat more serum accumulation in the wound. In one of the patients there was extrusion of catgut knots for about one month after operation.

In three operations on the breast the gelatin sponge was especially useful for controlling oozing from the breast tissue after biopsy or removal of benign tumors. Some mattress sutures were required to hold the sponge in place. In one case the gelatin sponge was used after removal of a large fibroadenoma to fill in a dead space which would otherwise have produced a marked depression of the breast.



Fig. 4—Gelatin sponge packed into biopsy wound of thyroid. This controlled the bleeding from the wound. As a precaution the sponge was held in place by several mattress sutures. (The diagnosis proved to be seruma lymphomatosa.)

In five rectal operations the gelatin sponge was of use as a pack after hemorrhoidectomy, fistula operations, and an anal plastic for imperforate anus. The sponge is apparently rapidly liquefied in the rectum and eliminates the necessity for removing the usual type of pack which is seldom a comfortable procedure for the patient, and which may sometimes be inadvertently overlooked. We would like to mention one experience with soluble cellulose as a rectal pack after hemorrhoidectomy. On examination the following day, it was found to have formed an airtight plug which had the consistency of dried glue. It was dislodged from the rectum with some discomfort to the patient. We are inclined to believe that this is one place where soluble cellulose is most definitely contraindicated.

The gelatin sponge was used on dermatome donor areas in nine cases. It stopped the bleeding promptly with or without thrombin. In most of the cases the gelatin sponge was liquefied in a few days where it had been in contact with the raw surface of the dermis. In a few instances the gelatin sponge

dried out and formed a firm covering which remained until the donor area was healed

Gelatin sponge has been used to control bleeding where excessive granulation tissue has been cut away in preparation for skin grafting. Under such circumstances the gelatin sponge is relatively rapidly absorbed within a few days, so that it is not necessary to remove the gelatin sponge preparatory to skin grafting.

Another use for gelatin sponge which we have found is as a vehicle for penicillin. It was used in ten cases and by and large the results were favorable in so far as penicillin can be expected to be of use locally. These cases included infected granulating wounds which were prepared for grafts, and ulcerated lesions of the leg which were refractory to other forms of treatment. The sponge was soaked in sterile physiologic saline solution in which varying concentrations of penicillin were added. After removal of an from the sponge the solution was not expressed from the sponge as was done when it was used for hemostasis. The sponge was then applied on the wound. Some covering dressing was required to hold it in place. Within twenty-four hours the sponge was usually liquefied to a considerable extent wherever it was in contact with the wound. Where the sponge overlapped normal skin it was not appreciably affected. The sponge was usually reapplied daily or at least every other day.

COMMENT

From these experimental studies we have been impressed with the observation that gelatin sponge apparently has hemostatic properties *per se*. This may be due to the enormous surface area of the myriads of interstices into which the blood may seep. This vast surface area may be a purely mechanical factor which aids in the clot formation from the bleeding wound. We do not wish to underestimate the usefulness of thrombin but merely to point out that what has been considered merely as the vehicle for the thrombin has in itself a hemostatic action which has not been fully appreciated. It is fair to conclude, however, that some additional hemostatic effect is undoubtedly obtained by the use of thrombin which may not have been easily detectable in our work, in view of the extensive data which have been presented in favor of the use of thrombin. It is therefore recommended that thrombin be added to the gelatin sponge wherever it is used in clinical cases for the purpose of controlling bleeding.

According to Friantz the use of thrombin with soluble cellulose is not only unnecessary but also contraindicated. The acid reaction of the cellulose negates the activity of the thrombin and if one uses an alkaline solution as a preliminary rinse before adding the thrombin solution, this nullifies the specific hemostatic action of the cellulose which is a property of the acidity of the material. Furthermore, the best hemostatic action of the soluble cellulose is obtained when it is applied in a dry condition to the bleeding surface.

In the clinical use of gelatin sponge we have been guided by the principle that it should not be relied upon for hemostasis in any condition in which a ligature or suture would ordinarily suffice. It has been used as a supplement to ligature or where ligature was not appropriate. When a large number of

- 8 Light, R U, and Prentice, H R Gelatin Sponge, Surgical Investigation of a New Matrix Used in Conjunction With Thrombin in Hemostasis, Arch Surg 51 69 77, 1945
- Light, R U, and Prentice, H R Studies in Neurosurgical Hemostasis, Surgical Investigation of a New Absorbable Sponge Derived From Gelatin for Use in Hemostasis, J Neurosurg 5 435-455, 1945
- 9 Jenkins, H P, and Clarke, J S Gelatin Sponge, A New Hemostatic Substance, Studies on Absorbability, Arch Surg 51 253, 1945

ADDENDUM

Since this work was submitted for publication some additional data have been obtained. In collaboration with Janda, and subsequently with Senz and Owen, wounds of the vena cava were made in dogs. In twenty-one out of twenty-three experiments the hemorrhage could be controlled by a gelatin sponge "patch" applied over the wound with finger pressure for two to four minutes. This "patch" usually became adherent to the vein, sealing off the wound until it healed over, and subsequently underwent absorption. One secondary hemorrhage occurred in this series. In two instances the hemorrhage could not be controlled.

In collaboration with Senz and Owen, a series of seventeen experimental wounds were made in the aorta of dogs. It was found that the hemorrhage could be controlled and the blood flow restored by a "cuff" of dry, compressed gelatin sponge held in place by four chromic catgut ligatures. Blowouts subsequently occurred after four to six days because of the friability of the sponge. When the sponge was supported by an absorbable sheath of chromic catgut, the blowouts were prevented in nine out of ten animals. In one of these a propagating thrombus was found adherent to the wound in the vessel.

In collaboration with Owen and Senz, wounds of the heart were made in a series of twelve dogs. Some of the wounds were large enough to admit the tip of a finger into the ventricle. The hemorrhage was controlled by the application of a dry, compressed patch of gelatin sponge. After twenty to thirty minutes the patch was usually adherent to the heart. There was no secondary hemorrhage or blowouts in these experiments. The twelve animals of this series survived or were sacrificed from two to forty days after operation.

These additional experiments were done without the use of thrombin and support the view that the gelatin sponge has hemostatic properties per se. This work will be reported in detail elsewhere.

MULTICENTRIC ORIGIN OF INTRAORAL CARCINOMA

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THE present-day treatment of intraoral cancer has resulted in such a discouraging outlook that an evaluation of the factors of therapeutic failure seems indicated. Emphasis has perhaps been placed rightly on the occurrence of cervical node metastases as a cause of failure, but local recurrence is likewise a serious factor in failure of cure. Although in recent years treatment methods used for control of the primary lesion have increased greatly in efficiency, it is obvious that no patient can be cured unless the disease is obliterated at its site of origin. True as this may seem, there is a tendency to lose sight of this fact, and to minimize the factor of persistence, or recurrence, of cancer at its primary site. Two recent publications have brought out this factor without emphasizing it. Martin, Munster, and Sugarbaker,¹ in a review of 498 cases of lingual cancer, reported only a 45 per cent rate of five-year cure in 191 patients of this group who never at any time in the course of their disease showed evidence of metastases. Their rate of five-year cure in the 498 patients reported was 25 per cent. In their figures of patients with proved metastases who were not cured, it is not indicated how many had persistent cancer at the primary site. Their reported 45 per cent rate of five-year cure in those patients without metastases would indicate numerically a 55 per cent failure of control of the primary lesion, which indicates a high rate of failure. Lawrence and Brezina,² in a review of 108 patients with cancer of the oral cavity treated during a ten-year period at the New Haven Hospital, reported for the entire group a 68 per cent failure to control the primary lesion. This figure includes the earliest treatment, in 1931, and is probably not a fair reflection of more recent results.

These considerations have prompted a study of the causes of failure in control of the primary lesions in patients with intraoral cancer. In the last two years eighty such patients have been treated at the tumor clinics of the Illinois Research and Presbyterian Hospitals. Although not suitable for any kind of end-result reporting, it is already apparent that in this group the experience will be essentially similar to that reported elsewhere.

It must be admitted that poor results are being obtained throughout the country in spite of the fact that during recent years methods of delivery of cancerocidal tumor doses of gamma and x-radiation have been improved, and ingenious operations have been devised to effect anatomic circumvention in the excision of intraoral cancers. This report is concerned with observations of the biologic behavior and histogenesis of these tumors in their relation to local recurrence.

Close observation of the location, patterns of spread, and recurrence behavior of these intraoral cancers has led me to an interpretation of their method

of growth which is at variance with the generally accepted tenets of cancer teaching. It is generally considered that a malignant tumor grows by multiplication of pre-existing cancer cells, and spreads by invasion and destruction of surrounding tissue. Description of these two mechanisms might constitute a definition of a malignant tumor, but such a simplified concept does not explain all the aspects of the growth and recurrence of carcinomas of the oral mucous membranes. Origin of these lesions from multicentric foci of epithelial change, and their spread by progressive lateral cancerization, is a concept that would explain many of the local recurrences following treatment of intraoral cancer. The term "multicentric origin" refers to the origin of tumor cells at multiple points in a given area of mucous membrane. These separate foci of neoplastic change may be close together in a small area, or widely separated. If close together the separate foci of origin would coalesce as growth proceeded, and form a single tumor. If widely separated, independent multiple tumors would result.

The term "lateral cancerization" refers to growth at the edges of a tumor by a process of progressive transformation into cancer of the epithelium, rather than progressive destruction of the epithelium by pre-existing cancer cells. Lateral cancerization may occur by two methods, either through multicentric foci of independent epithelial change, or through a carcinogenic effect of cancer cells on benign epithelium. This latter mechanism is conjectural, but it is believed that multifocal origin of intraoral cancer is demonstrable. Multiple foci of epithelial change into neoplasia occurs in various stages, and maturation of such a process does not occur simultaneously at various points in a given field of epithelium. Thus, the time element enters and explains the progressive character of such a process. Such a concept of the origin and growth of cancer is contrary, however, to the traditional view of the mechanics of cancer spread.

This concept of lateral cancerization is not new, but has been discussed and dismissed in the older literature as not being correct. Ribbert and Adams have both condemned it. Ewing³ has entertained it as a possibility for which there is no adequate proof. Recently Brunschwig has reopened the problem and has submitted experimental evidence demonstrating these factors of multicentric origin and lateral cancerization in induced skin cancer in mice, and in a spontaneous skin cancer in a human subject (Brunschwig and Tschetter,⁴ and Brunschwig and Thornton⁵). Willis^{6, 7} has published a thorough study of the origins and spread of skin cancer in human subjects in which he concluded that such tumors not only arise in multiple foci of origin which coalesce to form a single lesion, but that such lesions increase in lateral extent mainly by progressive transformation into cancer of the marginal benign epithelium.

A study of these eighty cases has yielded data supporting these views as being important factors in the origin and spread of intraoral cancer. This study has been carried out from two standpoints, first, a review of the topography and anatomic extent of the primary lesions and, second, microscopic study of all pathologic material available. In classifying the lesions as to site of origin, the very extensive ones were classified according to the site of the center of the tumor, which seemed appropriate because many of these neoplasms involved widely the mucous membrane of contiguous structures. Two of the patients

TABLE I TUMORS IN EIGHTY PATIENTS

ANATOMIC DISTRIBUTION		MICROSCOPIC EVIDENCE OF MULTIPLE ORIGIN	GROSS EVIDENCE OF LATERAL SPREAD GREATER THAN DEPTH
Base of tongue	7	0	7
Extensive disease	2	1	2
Soft palate	14	0	14
Central palate	2	1	2
Gingiva	13	8	12
Floor of mouth	5	1	5
Buccal mucosa	5	3	5
Tongue	18	8	11
Multiples	14	9	14
Total	80	31	72

had intraoral cancer of such an extent as to defy classification. These two will be discussed in detail later. The anatomic distribution of the tumors in the cases studied is shown in the first column in Table I. It will be noted that the last entry is listed as multiple tumors. The anatomic location of these multiples is listed separately in Table II.

TABLE II ANATOMIC LOCATION OF MULTIPLE TUMORS

CASE NUMBER	LOCATION OF TUMORS
1	Tonsil and gingiva
2	Tonsil and gingiva
3	Floor of mouth and tongue
4	Bilateral buccal mucosa
5	Antrum and opposite gingiva
6	Lip and tonsil
7	Floor of mouth and tonsil
8	Tongue and esophagus
9	Lip and buccal mucosa
10	Lip and buccal mucosa
11	Tongue and floor of mouth
12	Bilateral buccal mucosa, tongue, and floor of mouth
13	Tongue anterior and posterolateral
14	Tongue anterior and posterolateral

GROSS APPEARANCE OF TUMORS

Study of the size, shape, and extent of the primary sites of these tumors brings out one finding of significance. The majority of even the advanced and late lesions has a much greater involvement of the surface than of the deep tissues. This characteristic does not seem compatible with the hypothesis that centrifugal expanding growth with invasion and destruction is the only mechanism of local extension of a tumor of mucous membrane. Although tissue barriers, such as bone or fascia, may delay or deflect expansile growth, this does not seem to explain the distinct tendency to lateral spread involving mainly the mucous membrane. Of the eighty cases studied, this tendency to lateral spread in the mucosa was found in seventy-two, as determined by the gross aspect of the tumors in situ. In the third column in Table I is listed the number of tumors, according to primary site, which was considered to show considerably greater lateral extent than extent in depth. This fact alone may or may not be significant as evidence for lateral spread by progressive canceriza-

source. Neither were they in areas to which metastasis could occur. A process of progressive lateral cancerization seems to be the only reasonable explanation that could account for such distribution.

MULTIPLE TUMORS

Previous studies⁸ of multiple tumors have proved that this phase of the multicentric origin of tumors is more important than has been generally appreciated. In the patients reviewed in this study, fourteen out of eighty had

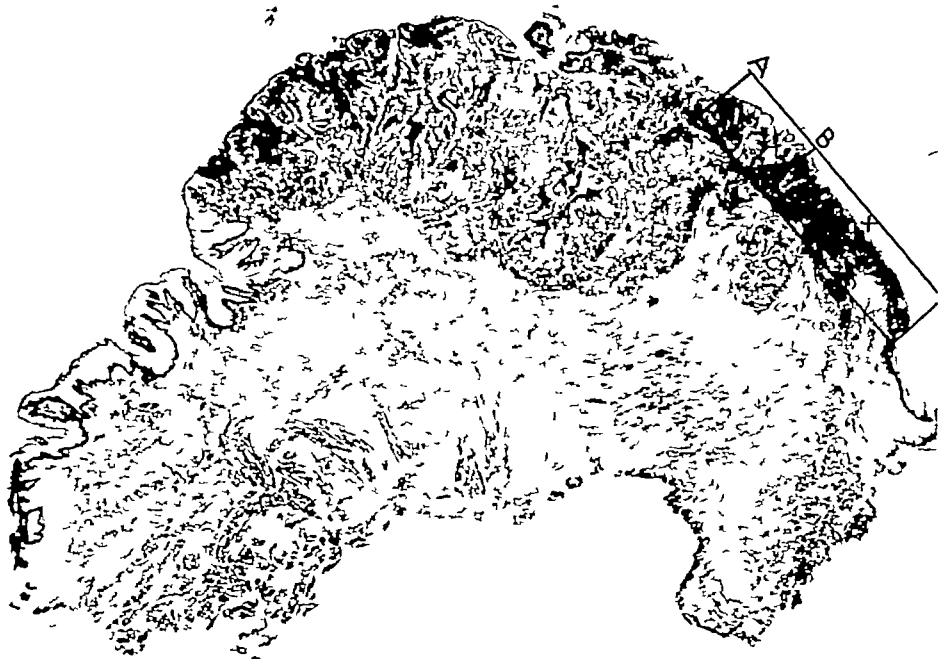


Fig 4—Low-power photomicrograph of cross section of excised carcinoma of the tongue. The lesion is shown to be moderately infiltrating but still of distinctly greater lateral extent than extent in depth. At either margin of the carcinoma there is a wide area of benign but thickened and hyperplastic epithelium. The boxed area to the right includes an extension of the lesion which is noninfiltrating and represents intraepithelial epidermoid carcinoma in situ.

multiple, independent malignant tumors involving the oral or pharyngeal mucosa, an incidence of approximately 18 per cent (Table II). These patients had multiple epidermoid carcinomas so situated that one lesion could not have originated by direct extension from the other. There are two possibilities which could relate such lesions, either lymphatic metastasis to other areas of mucosa, or implantation of surface cells carried by the oral secretions. The well-known metastatic patterns of intraoral cancer make it highly unlikely that metastasis would or could appear in separated areas of mucosa, particularly in the opposite side of the mouth. As to the implantation of cancer cells into a normal, or even broken mucosa, experimental evidence and experience with transplantation of animal tumors make this so improbable that it practically can be precluded even as a possibility. None of the multiple tumors described herein were of the so-called "kissing cancer" type, that is, representing two tumors lying in contact

with each other but with no neoplastic connections. Whether or not this is implantation cancer is debatable, therefore, these fourteen patients are described as having true multiple tumors. Such cases demonstrate the factor of multicentric origin, and their incidence of 18 per cent in this small series indicates the importance of such a factor in tumor growth, although the number of cases is too small to be of serious statistical significance.



Fig 5—High-power photomicrograph of area boxed in Fig 4 extending from A to B. This is the junctional zone between the infiltrating and keratinizing epidermoid carcinoma to the left and the intraepithelial cancer to the right, whose extent is delimited by the area of the box in which point x is located.

The majority of these patients with multiple tumors had only two separate lesions. One patient, however, had seven intraoral cancers in three years. When first seen, at the age of 30, she had an extensive squamous-cell carcinoma involving most of the right buccal mucosa, which was treated with intraoral x-radiation. There was fairly extensive leucoplakia throughout the oral mucosa. She remained well one year and then complained of severe pain in the opposite cheek. This pain continued and a trophic ulcer appeared in the left buccal mucosa, opposite the area previously treated. Biopsy of this revealed no cancer, but three months later the lesion was excised and at that time was composed of undifferentiated epidermoid carcinoma. One year later the patient presented five new and separate small foci of carcinoma. One was located on the dorsum of the tongue and measured 2 cm, one was on the right tonsil, measuring 5 mm, one was in the right floor of the mouth, measuring 1 by 1.5 cm, and two minute areas were on the buccal side of the mucosal lining of the lower lip, in the anterior gutter. These were biopsied and treated with radon seeds with com-

plete regression. At the time of death this patient was clinically free of intraoral cancer, but she had advanced bilateral cervical node metastases. Biopsies of two of these lesions showed what appeared to be origin of the carcinoma in several foci from the overlying surface epithelium. The leucoplakia in this patient's mouth was extensive, and after observing her throughout the disease, one had the feeling that almost the entire oral mucosa in this patient would eventually have undergone malignant transformation had she lived long enough.

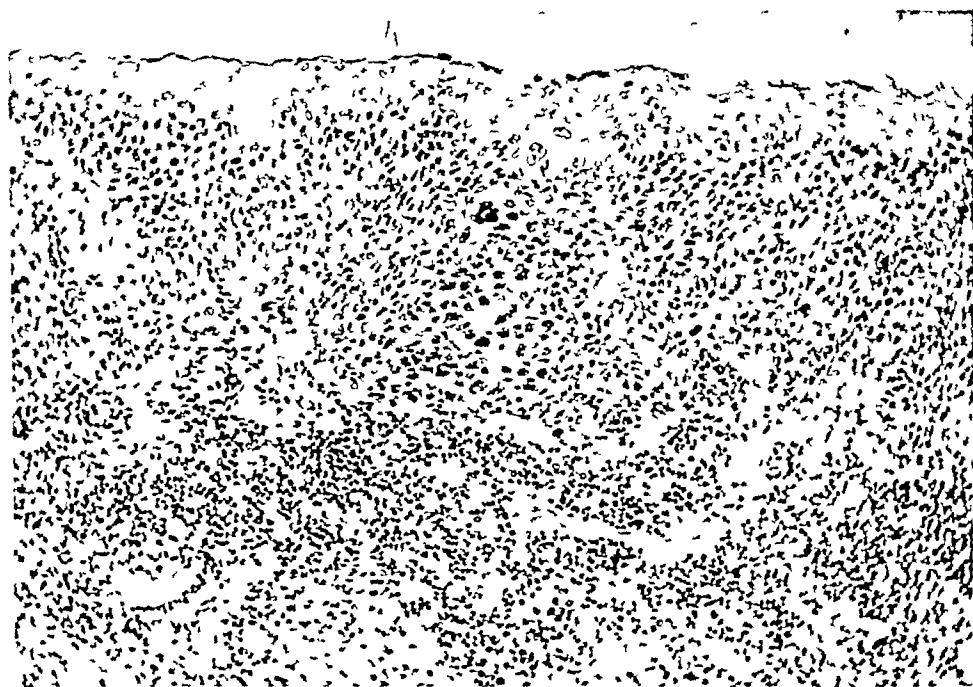


Fig. 6—High-power photomicrograph of epithelium at point marked *x* in Fig. 4. Here is shown intraepithelial epidermoid carcinoma in situ. As seen in Fig. 4 this area extends for some distance past the invading cancer.

MICROSCOPIC FINDINGS

Study of the pathologic material available on the eighty patients in this series produced further evidence indicating that multicentric origin and/or lateral cancerization are factors operating in the spread and growth of intraoral cancer. Since the treatment of intraoral cancer is mainly by irradiation methods, only small biopsy specimens were available for study from most of the tumors. These biopsies were routine specimens and were not removed in any deliberate manner with this study in mind. In fourteen of the patients complete excision was done, and in these cases the entire excised tumor was available for study. The microscopic examination was carried out with three points in view, first, evidence of origin of tumor from superficial epithelium, especially in more than one area, second, study of the junctional zone between benign and malignant epithelium, and third, the condition of the epithelium in the benign periphery of the tumor.

Biopsy Specimens—The small biopsy specimens were not very satisfactory for study because most of them were taken from the central ulcerated area of the tumor and showed nothing but solid tumor tissue, from which no conclusion could be drawn other than the diagnosis of cancer. Twenty-one of the small biopsies, however, which included nonulcerated tumor or some benign epithelium showed evidence of origin of the malignant cells from the overlying surface epithelium in two or more areas. Such evidence was based on the presence of



Fig. 7—Cross section of excised mandible with recurrent carcinoma of the overlying gingiva and adjacent buccal mucosa (see text for history of case illustrated in this and the following figures). The alveolar ridge is gone, from previous tumor and radiation and the "recurrent" tumor is seen to be confined to the epithelium and submucosa. To the right the epithelial change can be seen extending upward onto the buccal mucosa. The epithelial change is a diffuse one and in this section appears to be arising at many separate points.

microscopic fields with tumor cells showing invasion beyond the basement membrane of apparently benign surface epithelium, the invasive cells being in direct continuity with the overlying epithelium. Most of the sections showed areas which, taken alone, would represent "early cancer." The surface epithelium is eventually destroyed by extensive growth, but in early lesions the tendency is downward and not upward invasion. It is, therefore, considered reasonable to believe that small cell nests exhibiting downward invasion through

the basement membrane, but still in continuity with the epithelial layers, are evidence of origin of these cells from the epithelium at that point. Demonstrable isolated origin of tumor cells from the surface epithelium in only one section is inferential evidence of multicentric origin of the tumor, because the rest of the tumor must have come from other cells. The presence of two or more areas showing origin of tumor cells from the surface epithelium is more adequate evidence of multicentric origin. It is probable that biopsies taken deliberately from the periphery of tumors, and in larger sections, would show microscopic evidence of multicentric origin in a considerably higher proportion of the tumors. Study of the totally excised lesions would tend to bear this out.



Fig 8—Low-power photomicrograph of full thickness of cheek excised in continuity with the mandible shown in section in Fig 7. The top surface shows replacement of the epithelial layer by a diffuse, low-grade epidermoid carcinoma. This area of the tumor is in part intra-epithelial in situ cancer and partly invasive. Such an area of tumor could hardly have arisen from one cell or from one small area. The picture of atypism to a degree diagnosable as carcinoma is essentially in the basal cell layers while the superficial layers are apparently still benign and nonulcerated.

Surgical Specimens—Fourteen specimens excised from the eighty patients were available for study. Thirteen of these specimens showed microscopic evidence of origin of the tumor at multiple points from the superficial epithelium. Thirteen of them showed lateral linear extent considerably greater than their extent in depth. The thirteen neoplasms in each list are not identical, as one tumor of the flat type did not show origin of tumor cells from the surface epithelium, and the one tumor of the invasive and expansile type did show such a picture. Obviously there was some difference in the clinical picture of the fourteen patients treated surgically as compared to the sixty-six patients treated by irradiation. In six of the patients the tumors were treated by surgical methods because the lesions had failed to respond to irradiation or had "re-

curred" following irradiation, and in all six, bone was invaded by cancer. The other eight cases consisted of five small or superficial and accessible epidermoid carcinomas of the tongue, one of the buccal mucosa of the upper lip, and two of the buccal mucosa with invasion of the maxilla when first examined. Decision to utilize surgical excision primarily for the five lingual cancers was prompted by their accessibility, ease of removal, and quick healing as compared with the prolonged discomfort following radiation of such lesions.

Examination of the cross sections of these excised carcinomas showed that all except one were relatively flat, superficial tumors whose lateral linear extent was greater than their extent in depth. Higher power fields showed them to be unmistakably malignant and invasive, but it was equally obvious that the change was a diffuse one over a wide extent of epithelium. At the margins of the malignant tumor, the transition into benign epithelium was abrupt, yet for a variable distance this benign epithelium showed distinct hyperplasia. In a few



Fig 9—High-power photomicrograph of area boxed in Fig 8. Here is shown both invasive and preinvasive epidermoid carcinoma. The epithelial change is a diffuse one involving many cells at once, and the neoplastic activity is not arising from any central source of centrifugal expansion.

sections this hyperplasia was atypical, and in some could be classified as intra-epithelial carcinoma in situ. In three of the lesions excised primarily, there were areas of benign epithelium interspersed between areas of frankly invading cancer (Figs 1 to 6). In the one tumor which on cross section showed invasion equal to lateral extent, the junctional zone between malignant and benign epithelium showed what was interpreted as evidence of origin of the tumor cells from the surface epithelium.

The most thought-provoking finding from this study is the evidence of multiple origin of tumor cells from the surface epithelium in the recurrent cancers. Of the six lesions excised because of "recurrence" and bone invasion, three actually represented persistence and/or growth and extension during and after irradiation. The other three tumors recurred one, one and one-half, and three years, respectively, following the original therapy. The usual concept of local recurrence of cancer is that it is due to residual cells not removed by surgery, and not destroyed by irradiation, these cells resume their growth capacity and produce a new tumor as a continuation of the original one. The findings here recorded by no means invalidate this concept, but they do suggest that there may be another mechanism which occasionally explains the recurrence of intraoral epidermoid carcinomas. This mechanism would be the progressive transformation into cancer of benign epithelium which has healed over the site of a destroyed cancer.

One case particularly illustrated the possibility of such a mechanism. The patient had an epidermoid carcinoma of the right lower gingiva, with erosion and exposure of the underlying alveolar ridge. In spite of the evidence of bone involvement, he was treated with x-rays through an intraoral cylinder with apparently complete regression of the tumor. Within six months after the radiation reaction had subsided the *area was healed* and the exposed bone covered by epithelium. Three months later the area irradiated was covered with fairly heavy leucoplakia. This was biopsied at a subsequent visit and proved to be benign hyperplasia. Three months later the leucoplakia had become much thicker and had extended across the buccal gutter well up on the buccal mucosa. Biopsy now showed squamous-cell carcinoma. Excision of full thickness of the cheek and the mandible was carried out. Sections of the tumor are shown in Figs 7, 8, and 9. The low-power view of the whole thickness of the cheek showed a low-grade, superficial, extensive epidermoid carcinoma, intraepithelial in some areas and invasive in others. The topography of the lesion made it improbable that such a neoplasm could have arisen either from one or many tumor cells which retained their growth potential following the original roentgen treatment. It is equally unlikely that such a tumor could have originated from a single central source, either of residual cancer or of an entirely new tumor.

DISCUSSION AND IMPLICATIONS

Study of the anatomic extent and gross appearance of the tumors in eighty patients with intraoral cancer showed that the majority of such lesions were relatively flat with definitely greater linear extent than extent in depth. In 18 per cent of the eighty patients there occurred at least two epidermoid carcinomas, separated by areas of normal mucosa adequately wide to allow definition of them as independent lesions. In the small biopsies from this series of patients, there was found evidence in twenty-one of origin of tumor cells from the benign surface epithelium in more than one area. Fourteen of the patients had surgical excision of the tumors. In this group thirteen showed lateral extent greater than depth, and thirteen showed origin of the tumor from multifocal contiguous areas of surface epithelium. Some of these foci of origin in the

periphery of the tumors were isolated and surrounded by benign epithelium. In every instance where the entire tumor was available for study, the peripheral benign epithelium was found to show a marked degree of hyperplasia, atypical in a few instances to a degree allowing the diagnosis of intraepithelial carcinoma *in situ*.

These three factors, namely, lateral spread, multiple tumors, and microscopic evidence of multicentric foci of origin, would seem to suggest that another mechanism occasionally exists regarding the growth and spread of intraoral epidermoid carcinoma.

That the tumors illustrated here could arise from one cell, or one small focus of carcinogenesis, seems unreasonable. There is no question that a malignant cell divides and reproduces in a biologically relative form of geometric progression, yet this mechanism alone does not explain the behavior nor the distribution pattern of the epithelial changes in intraoral cancer.

These considerations also tend to show that epidermoid carcinoma not only does not arise from a single small focus in space, but neither does it arise in a single small unit of time. The sections represented here demonstrate multiple phases of epithelial change through all stages of carcinogenesis, from early reversible hyperplasia to frankly invading squamous-cell carcinoma. The process is a progressive one, both in a given field of tissue and in time relationship.

Horizontal spread of intraoral cancer by a process of progressive lateral cancerization would seem to be a double process, consisting of the division, growth, and multiplication of existing cancer cells, plus formation of a new foci of malignant neoplastic activity in the periphery of a tumor. This latter process is probably a self-limited one in time and space and is mainly demonstrable only in fairly early tumors. However, where a wide field of mucosa has been conditioned to progressive epithelial neoplasia, local "recurrences" of a tumor after treatment may often represent new foci of cancer arising independently at the edge of the treated or excised area.

There is suggestive evidence that recurrence of a carcinoma within the site of a previously treated tumor may be due to late neoplastic change occurring in epithelium which has grown in from the edges and covered the site of a previously destroyed tumor. Such epithelium may respond to the wound healing stimulus, retaining its latent neoplastic potential which later becomes manifest as "recurrence." Recurrent tumors frequently appear as superficial ulcerations, and not uncommonly are preceded by visible epithelial change in the form of leucoplakia. This possibility needs further observation and investigation.

SUMMARY AND CONCLUSIONS

Eighty patients with intraoral epidermoid carcinoma have been studied from the standpoint of origin and method of growth of their tumors, and in relation to local recurrence following treatment. The study resulted in three findings: first, most of the tumors were flat, with greater surface extent than

depth, second, 18 per cent of the patients had multiple independent primary tumors, third, microscopic study of biopsies and of whole specimens removed surgically shows evidence of multicentric origin of these epidermoid carcinomas. This multifocal origin is in relation to both space and time. The three sets of data together are evidence that many so-called local "recurrences" may in reality be new foci of cancer arising in the peripheral field of a previously treated tumor.

REFERENCES

- 1 Martin, H. E., Munster, H., and Sugarbaker, E. D. Cancer of the Tongue, Arch Surg 40 888-936, 1940.
- 2 Lawrence, E. A., and Brezina, P. S. Carcinoma of Oral Cavity, J A M A 128 1012-1016, 1945.
- 3 Ewing, James E. Neoplastic Diseases, Ed. 4, Philadelphia, 1940, W. B. Saunders Company.
- 4 Brunschwig, A., and Tschetter, D. The Mode of Inception and Lateral Spread of Certain Squamous Cell Carcinomas, Surg, Gynec & Obst 67 715-721, 1938.
- 5 Brunschwig, A., and Thornton, T. F. An Experimental Study of the Lateral Spread of Epidermoid Carcinoma in Man, Cancer Research 4 515-518, 1944.
- 6 Willis, R. A. The Mode of Origin of Tumors, Cancer Research 4 630-644, 1944.
- 7 Willis, R. A. The Mode of Origin of Tumors, Cancer Research 5 469-480, 1945.
- 8 Slaughter, Danely P. The Multiplicity of Origin of Malignant Tumors, Surg, Gynec & Obst 79 89-98, 1944.

PENICILLIN-PIHTHALYLSULFATHIAZOLE ANTAGONISM

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THE bacterial flora of the gastrointestinal tract is altered by the oral administration of sulfasuxidine and sulfathiazole^{1, 2} by lowering the gram-negative organisms and anaerobic bacteria. The sulfonamides have little or no effect on gram-positive organisms, especially *Streptococcus faecalis* and members of the *Salmonella* group of organisms.

Penicillin has activity against some organisms not affected by the sulfonamides. It has been demonstrated that penicillin is presumably destroyed by an enzyme, penicillinase, formed by *Escherichia coli*. After the number of

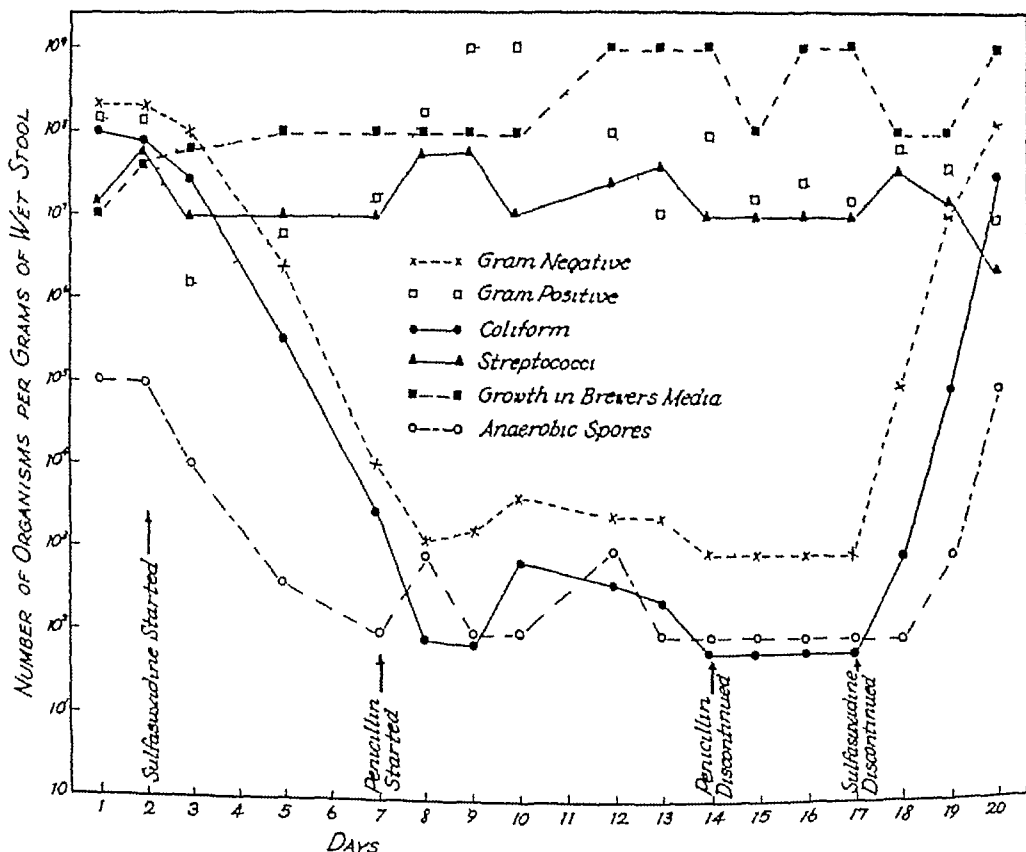


Fig 1—Chart illustrating the characteristic alteration of the bacterial flora of the bowel when 3.0 Gm of sulfasuxidine (succinylsulfathiazole) are given orally to an adult man every four hours, and the fact that the simultaneous intramuscular administration of 20,000 units of penicillin every two hours induces no further change in either the gram-negative or gram-positive flora.

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DIFFERENTIAL SPINAL BLOCK

A PRELIMINARY REPORT

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THE introduction of anesthetic agents into the spinal canal has, up to the present time, constituted an important aid to the surgeon in providing a useful type of anesthesia. However, from the physiologic point of view, this simple procedure is perhaps an undefined technique. Possible differences in susceptibility of the various kinds of fibers that traverse the subarachnoid space have not yet been adequately studied. If such differences in susceptibility should be established, the technique of subarachnoid injection would become more important as a therapeutic and diagnostic tool than it now is.

Anatomic consideration of the nerve fibers in the subarachnoid space, indicates that it should be possible to introduce into the spinal canal a concentration of procaine which would block autonomic nerves while affecting other types of fibers minimally or not at all.¹ This report is concerned with attempts to demonstrate this.

Gasser and Erlanger,² working with cocaine, and Heinbecker, Bishop, and O'Leary,³ working with procaine, have demonstrated that the class C fibers, the least myelinated of a mixed nerve are the first to be blocked when subjected to local infiltration with the anesthetic agent. It does not necessarily follow that these fibers (in which class autonomic fibers generally fall) are blocked by a lower concentration, but it does suggest that this is so and that, therefore, these fibers could be preferentially blocked.

Preliminary experiments in the cat indicated that this was true, since a powerful sympathogenic reflex, the carotid sinus reflex, could be abolished in the vagotomized cat by a 0.15 per cent procaine perfusion of the spinal canal (after the method of Coit⁴), at a time when the animal maintained spontaneous respiratory activity and gave a contralateral muscular response to the electrical stimulation of one femoral nerve.

MATERIAL AND METHOD

Six patients from the surgical wards of the Massachusetts General Hospital served as subjects. All were men ranging in age from 30 to 81 years, the average being 53 years.

At the beginning of the observational period the patient was brought into a room in which the temperature was constantly maintained at a given low level (between 15 and 20° C). The patient wore only a loin cloth. A needle was introduced into the spinal canal between the third and fourth lumbar vertebrae and connected with rubber tubing for continuous intraspinal administration.

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after the method of Lemmon⁵ Administration of procaine solution of the desired concentration and at any desired rate was then accomplished using the method and equipment described in a previous communication^{6,8}

Eight thermocouples were then placed as follows one thermocouple on the plantar aspect of each great toe, one on the lateral aspect of the dorsum of each foot, one each on the palmar aspect of the right thumb and middle finger, and two in different parts of the foot. The thermocouples were connected to a device which continuously recorded their temperatures and they remained in place for the duration of the experiment. The recording device was then started and adequate control levels were obtained. At this time the initial dose, 10 cc of a 0.2 per cent solution (20 mg) of procaine hydrochloride, was run in in about three minutes. Thereafter 15 drops per minute (0.6 cc or 12 mg) were allowed to run in until the desired effect or height of block was attained. The subsequent rate of administration was determined by the duration and level of the block desired. Blood pressure, pulse, and neurologic observations were made at regular intervals. In one patient determinations of the cerebrospinal fluid pressure were carried out by temporarily connecting a spinal manometer to the segment of tubing connected with the spinal needle.²² The zero point for the manometer was arbitrarily chosen as the level of the skin of the back so that all observations were a few centimeters too high, although relative deviations were accurately reflected. No other medication was given at any time.

The neurologic examination used during the course of these experiments was as follows. The appreciation of pinprick was elicited with a sharp needle, touch was ascertained by using the blunt end of the needle, a delicate camel's-hair brush, and finger pressure. Proprioception was determined by examining the patient's appreciation of toe position. Vibratory sense was examined by the use of the 256 tuning fork. Heat and cold sensation were examined by the use of heated and cooled steel rods. It should be mentioned that, at the temperature at which these experiments were conducted, the proper appreciation of heat and cold was impaired prior to the induction of the differential spinal block. Therefore, in subsequent parts of this paper when it is stated that there is loss only of pinprick sensation, it should be remembered that impairment of temperature sense also may have been present. In each of the six cases studied the patient volunteered the information that his feet were getting warm when the skin temperature rose and were getting cold again when the skin temperature began to fall (in those cases in which it declined appreciably toward the end of the experiment). At regular intervals the patient was asked to flex and extend his foot maximally and to roll his thighs medially and laterally as far as they could be rolled. He was asked to tense his abdominal muscles and to perform a full inspiration. The deviations from this outline in method are specified in the case reports.

The work of Landis and Gibbon^{9,10} and of Morton and Scott¹¹ indicates that in an individual in whom the skin temperature has been brought to below 24° C, any factor which then causes the skin temperature to rise to 31.5° C or above may be assumed to have caused a complete block of the vasoconstrictor nerve fibers to that area. We attempted to meet these criteria in our experiments.

RESULTS

The results indicate that a block of sympathetic fibers and those carrying impulses concerned with the appreciation of pinprick can be accomplished without affecting other forms of sensation (with the possible exception of thermal sense) or motor power, in so far as these impulses are reflected by the neurologic examination used

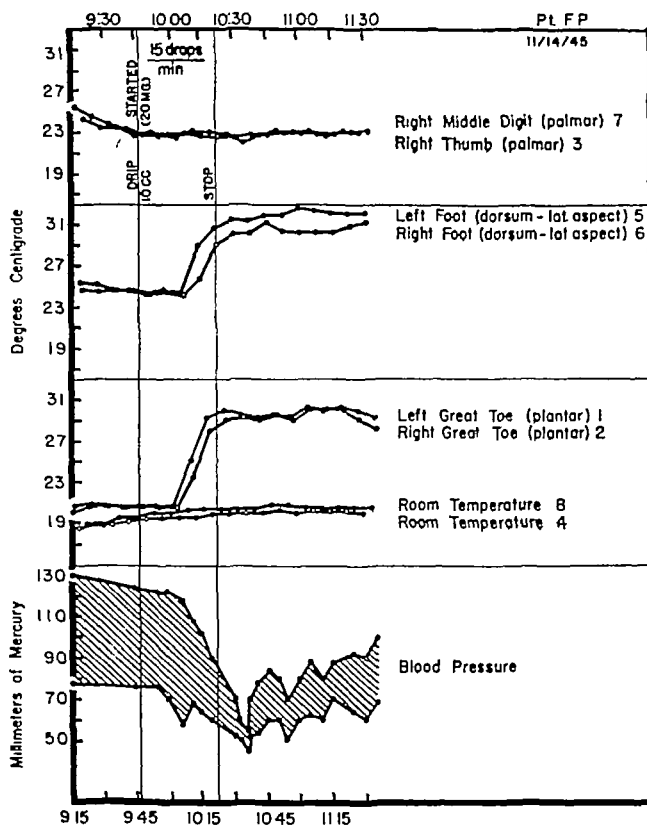


Fig 1

CASE REPORTS

CASE 1 (No 506033) —F P, 62 years of age, had carcinoma of the stomach (preoperative) (Fig 1). A lumbar puncture was performed at 9 10 A.M. and, satisfactory skin temperature levels being obtained, the initial dose of procaine was administered at 9 47 A.M. This was 250 drops (10 cc or 20 mg) and took three minutes to run in. The drip was then continued at the rate of 15 drops (0.6 cc or 1.2 mg) per minute. At 10 03 A.M. the skin temperature of the toes rose sharply. The skin temperature on the dorsum of the feet rose shortly thereafter. The temperature of the right hand remained the same. Coincident with the sympathetic block there was a barely discernible diminution of sensation of pinprick on the medial side of the upper portion of each thigh. There was no other loss of sensation and no apparent loss of motor power. Paralleling the rise in skin temperature there was a sharp fall in blood pressure. The sympathetic block persisted for 15 hours. Nausea and vomiting were not present at any time. The patient received a 20 mg initial dose and a 60 mg total dose over a period of thirty five minutes.

CASE 2 (No 436614)—G H, 30 years of age, had a hemorrhoidectomy (seven days postoperative) (Fig 2) A lumbar puncture was performed and a continuous spinal needle was inserted between the third and fourth lumbar vertebrae at 10 40 A M At 11 11 A M, 10 cc (20 mg) of procaine hydrochloride were allowed to run in The drip was then set at 15 drops per minute At 11 50 A M the rate was changed to 20 drops per minute and at 11 53 A M there was a sharp rise in skin temperature of both lower extremities Twenty three minutes prior to the rise in skin temperature, impairment of the appreciation of pinprick began to manifest itself in the first sacral segment This increased and at the time of the rise in skin temperature it was at the level of the eleventh thoracic vertebra The temperature of the right hand remained the same throughout the experiment There was no other loss of sensation and there was no loss of motor power at any time during this experiment Paralleling the rise in skin temperature there was a moderate fall in blood pressure which rose again as the skin temperature fell The patient received a 20 mg initial dose and a 131 mg total dose over a period eighty two minutes

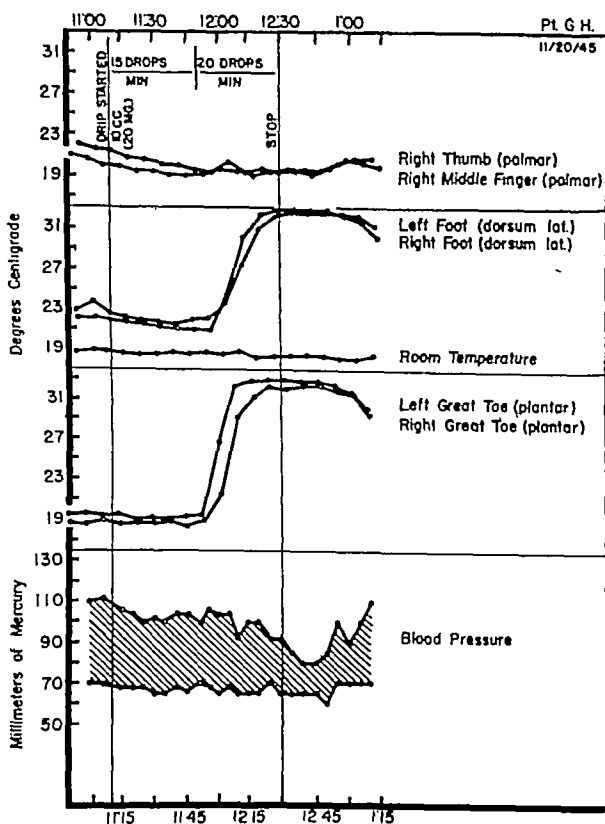


Fig 2

CASE 3 (No 511980)—W M, 38 years of age, had a right inguinal hernia (preoperative) (Fig 3) Satisfactory skin levels having been obtained, the intraspinal drip was begun at 11 27 A M Between then and 11 30 A M 300 drops (12 cc or 24 mg) were allowed to run in The dripper was then regulated at 20 drops per minute At 12 11 P M the skin temperature of both feet rose sharply The drip was discontinued at 12 45 P M Twenty six minutes prior to the rise in skin temperature there was beginning, spotty impairment of appreciation to pinprick in the right lower leg This gradually rose and at 12 55 P M it was at the fourth thoracic segment The temperature of the right hand remained the same throughout There was no other loss of sensation and no loss of motor power at any time during the course of

this experiment There was a slight fall in blood pressure paralleling the rise of the skin temperature to the lower extremities and this was accompanied by slight nausea and vomiting The initial dose was 24 mg of procaine hydrochloride The total dose was 144 mg of procaine hydrochloride over a period of seventy eight minutes The patient received a larger initial dose in terms of cubic centimeters as well as procaine hydrochloride and a larger total dose than any other patient in this series Measurements of the cerebrospinal fluid pressure showed that immediately after the initial dose there was a 6.5 cm. rise in pressure and at the end of the infusion there was a 1.5 cm. rise as compared to the pressure before any infusions were given

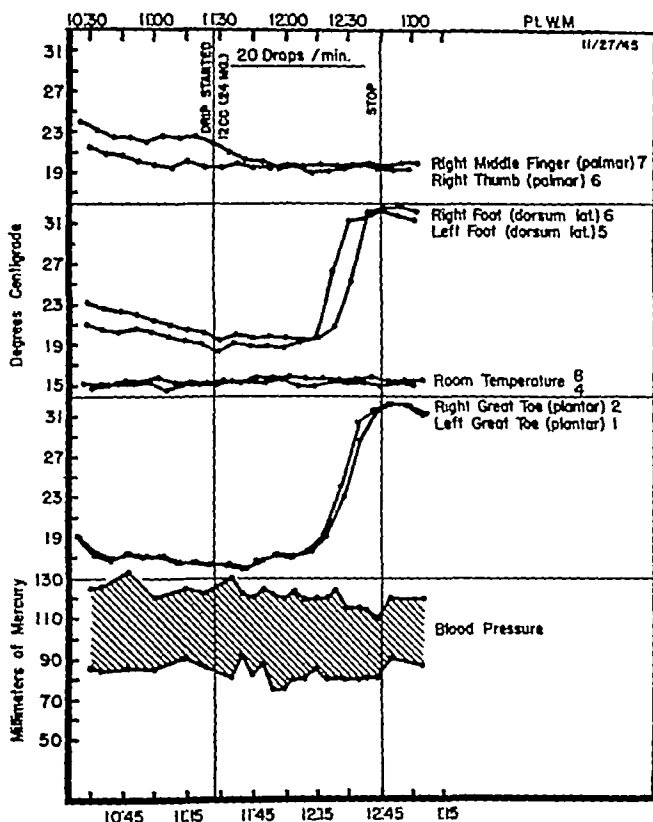


Fig 3

CASE 4 (No 381479) —S B, 81 years of age, had herpes zoster (Fig 4) The skin temperature values for the right thumb and middle finger (the initial portion of Fig 4) are to be disregarded inasmuch as the high values were obtained because the hand was allowed to lie on the chest When it was removed from the chest the skin temperature fell promptly to 23° C, as is seen in Fig 4 The initial dose of 8 cc of a 0.2 per cent solution failed to produce a rise in skin temperature although gradually diminishing appreciation of pinprick became apparent thirty minutes after the initial dose was given The initial dose was followed by the administration of 6 drops per minute and at 10 54 A.M. was changed to 10 drops per minute At 11 30 A.M. this was raised to 12 drops per minute and at 11 53 A.M. to 15 drops per minute This failed to induce a rise in skin temperature, and a 0.3 per cent solution was run in. The rate was then continued at 10 drops per minute At 12 45 P.M. the skin temperature of the feet rose sharply and there was a diminution of pinprick up to the level of the sixth thoracic vertebra There was no other loss of sensation There was no loss of motor power at any time during the course of this experiment The dripper was stopped at 1 44 P.M.

Paralleling the rise in skin temperature there was a sharp fall in blood pressure which rose again when the skin temperature began to come down. There were slight nausea and vomiting at the height of the sympathetic block.

This experiment was the first performed and accounts for the cautious initial dose and drip rate administered in the first portion of the experiment.

The preceding four experiments demonstrate that the lower portion of the thoracolumbar outflow was paralyzed in so far as this is indicated by a paralysis of the peripheral vasoconstrictor fibers.

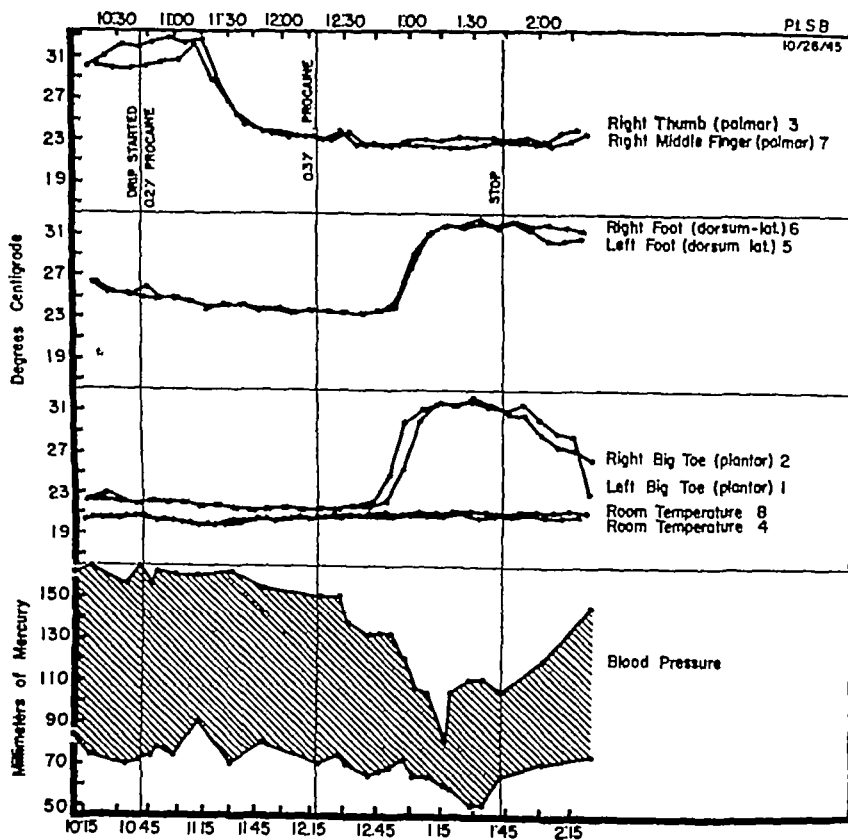


Fig 4

CASE 5 (No 382923) —R T, 54 years of age, had intractable amputation stump pain (Fig 5). Only four thermocouples were used in this experiment. Satisfactory skin levels having been obtained, the intraspinal drip of 10 cc (20 mg) of procaine hydrochloride was given in three minutes starting at 5:46 P.M. The drip was then continued at a rate of 15 drops per minute until 7:01 P.M. At 6:15 P.M. the skin temperature of the feet rose sharply and at 6:50 P.M. the skin temperature of the hand (right middle finger) also rose sharply. Impairment of the appreciation of pinprick began to diminish just prior to the rise in skin temperature in the lower extremity. This eventually (6:50 P.M.) rose to the third thoracic segment. Paralleling the rise in skin temperature there was a moderate fall in blood pressure. Slight nausea and vomiting were noted at this time. Accompanying the loss of pinprick and the rise in the skin temperature the patient volunteered that he was experiencing the first relief of the amputation stump pain that he had had for several months. This lasted for three to four hours following the induction of the block. There was no other loss of sensation and no loss of motor power at any time during the course of this experiment. The total dose was 106 mg. in seventy five minutes.

CASE 6 (No 509346) —W S, 53 years of age, had carcinoma of the stomach (preoperative) (Fig 6) At 2 30 P M, satisfactory skin temperature levels having been obtained, the initial dose of 10 cc (20 mg) procaine hydrochloride was administered intraspinaly in three minutes At 2 52 P M the rate was slowed from 15 drops per minute to 10 drops per minute and this rate was continued until 3 30 P M Seven minutes after the initial dose the skin temperature of both feet rose sharply As the concentration of the drug rose in the upper portion of the spinal canal, complete block became manifest in the upper as well as the lower portion of the thoracolumbar outflow Paralleling the rise in skin temperature there was a moderate fall in blood pressure which rose again as the skin temperature began to fall In this patient the rise in skin temperature preceded by a few minutes the loss of appreciation of pinprick in the areas of the second and third lumbar segments Eventually the loss of appreciation of pinprick rose to the second thoracic segment The drip was stopped at 3 30 P M There were moderate nausea and vomiting during the periods of hypotension and sympathetic block There was no other loss of sensation and no loss of motor power at any time during the course of this experiment The initial dose in this patient was 20 mg, the total dose 76 mg, over a period of sixty minutes

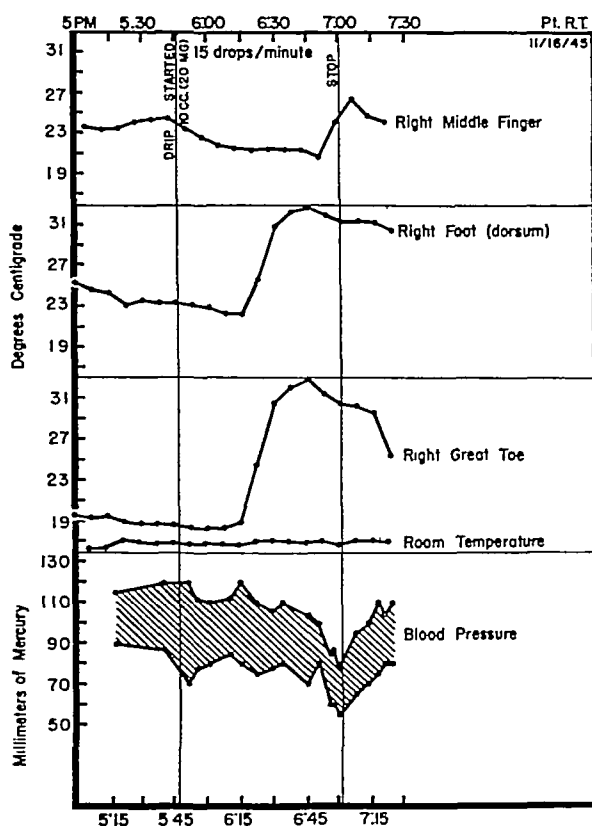


Fig 5

Comment —Cases 5 and 6 demonstrate that it is possible to block not only the lower portion of the thoracolumbar outflow, but the upper portion of the thoracolumbar outflow as well, without blocking sensory fibers other than those concerned with pinprick and without causing motor loss In Case 6, where there was a complete block of the upper portion as well as the lower portion of the

thoracolumbar outflow, it is justifiable to assume that all the areas in between the upper and the lower portion reacted in the same fashion. In this case, then, we have an experimental preparation in which there are apparently no impulses traveling over the fibers carrying vasoconstrictor impulses to the periphery.

Three patients experienced a loss of sensation to pinprick appreciably before the rise in skin temperature, and the interval between the two end points was long enough to be sure that they were separate phenomena. In two other patients the apparent sympathetic block and the loss of sensation of pinprick came at about the same time. In the sixth patient there was but a circumscribed, minimal loss of pinprick sensation at a time when the lower sympathetic block was complete.

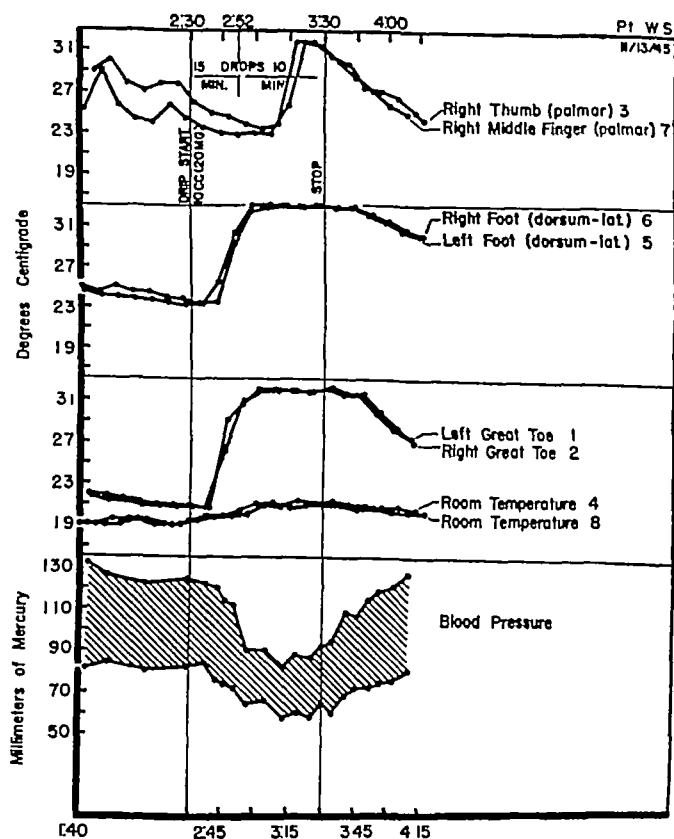


Fig. 6

Nausea and vomiting were present in four of the six patients studied. These symptoms were absent in two patients, one of whom had a profound fall in blood pressure, in fact, the largest encountered in this series. Nausea and vomiting occurred in one patient in whom the fall in blood pressure was negligible. The pulse rates are not revealing for, although a tachycardia might have been expected in the presence of the low arterial pressure and low filling pressure of the right ventricle and great veins, nevertheless, it is to be assumed

that there is a sufficient amount of procaine high enough in the spinal canal to affect materially the impulses transmitted by the cardiac accelerator fibers. This effectively blocks the reflex activity of the carotid sinus and great veins, the main homeostatic mechanisms under conditions of hypotension. Making this assumption carries with it the implication that cardiac accelerator fibers are blocked by a lower concentration of the agent than the peripheral vasoconstrictor fibers, since a relative bradycardia was present in four patients in whom vasodilatation of the fingers did not occur.

A differential spinal block was given to twenty-four additional patients, the findings did not differ materially from those of the six described in this paper. The details of these twelve cases will be given in a later communication in which the use of the method in diagnosis and therapy is described.²²

Hypotension in Spinal Anesthesia—It has been suggested^{12, 13, 14} that the fall in blood pressure following the induction of spinal anesthesia is due to the muscular flaccidity accompanying it, since this leaves the vascular bed unsupported and deprives the veins of their normal support and massaging action, with consequent lowering of venous return, cardiac output, and arterial pressure. It has also been maintained that paralysis of the intercostal muscles limits thoracic excursions thereby decreasing the aspiratory action of the thorax, thus diminishing venous return, cardiac output, and arterial pressure.^{13, 14, 15} In our group of patients sympathomimetic drugs were not given. The hypotension following the induction of the differential block was equal to that seen with the undifferentiated block in which no drug therapy is given.^{12, 16} Yet we did not encounter motor block of any kind at any time during these experiments, and it would seem that both of these interpretations become unlikely in the light of this and other evidence.^{16, 19} If, then, we may be permitted to discard the loss of appreciation of pinprick as not significant in regard to hypotension, it would seem certain that, as previously suggested by many authors, the hypotension following the induction of spinal anesthesia is the result of the paralysis of sympathetic fibers and the vascular dilatation consequent thereto. This evidence does not shed any light on which components of the vascular bed are most directly responsible.

Order of Nerve Block—The sequence of nerve block according to Maxson²⁰ and Evans²¹ is as follows: pain, temperature, touch, proprioception, motor and sympathetic fibers. Heinbecker, Bishop, and O'Leary,³ using more definitive methods, concluded that the block of nerves both in the spinal canal and peripherally occurred in the following sequence: vasoconstrictors, temperature, pain, motor, joint sense, pressure sense, and touch. By slowing down the sequence of events as they occur, with the use of a dilute solution, we are able to bring a finer focus to bear on this sequence. It will be seen from the cases which we have presented and from research now in progress that there is no single regular sequence of events but that either the sympathetic fibers or the fibers concerned with the appreciation of pinprick may be blocked first, occasionally as much as forty-five minutes occurring between the block of the two kinds of fibers.

SUMMARY AND CONCLUSIONS

1 It is possible to introduce a concentration of procaine into the sub-arachnoid space which will block the fibers carrying vasoconstrictor impulses to the periphery and also those concerned with pinprick without materially affecting fibers concerned with touch, proprioception, vibratory sense, or motor power. This is termed differential spinal block.

2 Hypotension during spinal anesthesia is not the result of muscular flaccidity or diminished thoracic excursions but is a result of the interruption of sympathetic vasoconstrictor fibers.

3 The determination of the level of the loss of sensation to pinprick yields only very approximate information concerning the level of block of other kinds of fibers.

REFERENCES

- 1 Sarnoff, S J Letter to the Editor, *Anesthesiology* 6 531 532, 1945
- 2 Gasser, H S, and Erlanger, J Role of Fiber Size in Establishment of Nerve Block by Pressure or Cocaine, *Am J Physiol* 88 581 91, 1929
- 3 Heinbecker, P, Bishop, G H, and O'Leary, J Analysis of Sensation in Terms of the Nerve Impulse, *Arch Neurol & Psychiat* 31 34 53, 1934
- 4 Co Tu, Burstein, C L, and Ruggiero, W F Total Spinal Block A Preliminary Report, *Anesthesiology* 1 280 291, 1940
- 5 Lemmon, W T A Method for Continuous Spinal Anesthesia, Preliminary Report, *Ann Surg* 111 141-144, 1940
- 6 Arrowood, J G, and Foldes, F F A Continuous Drop Method for Subarachnoid Analgesia Preliminary Report, *Anesthesiology* 5 465 469, 1944
- 7 Arrowood, J G, and Foldes, F F Subarachnoid Analgesia Maintained by the Continuous Drop Method, Preliminary Report, *Arch Surg* 49 241 244, 1944
- 8 Arrowood, J G, and Foldes, F F The Management of Subarachnoid Analgesia by the Continuous Drop Method, *Brit J Anesth* (In press)
- 9 Landis, E M, and Gibbon, J H A Simple Method of Producing Vasodilatation in the Lower Extremities, *J Clin Investigation* 52 785 808, 1933
- 10 Gibbon, J H, and Landis, E M Vasodilatation in the Lower Extremities in Response to Immersing the Forearms in Warm Water, *J Clin Investigation* 11 1019 1036, 1932
- 11 Morton, J J, and Scott, W J M Methods for Estimating the Degree of Sympathetic Vasoconstriction in Peripheral Vascular Diseases, *New England J Med* 204 955, 1931
- 12 Smith, H W, Rovenstine, E A, Goldring, W, Chassis, H, and Ranges, H A The Effects of Spinal Anesthesia on the Circulation in Normal, Unoperated Man With Reference to Autonomy of Arterioles, and Especially Those of the Renal Circulation, *J Clin Investigation* 18 319 341, 1939
- 13 Gray, H T A Study of Spinal Anesthesia in Children and Infants, *Lancet* 2 913, 991, 1909
- 14 Gray, H T, and Parsons, L Blood Pressure Variations Associated With Lumbar Puncture, and the Induction of Spinal Anesthesia, *Quart. J Med* 5 339, 1912
- 15 SeEVERS, M H, and Waters, R M Respiratory and Circulatory Changes During Spinal Anesthesia, *J A. M. A* 99 961, 1932
- 16 Koster, H Blood Pressure Changes During Spinal Anesthesia in Non operative Cases, *Arch Surg* 45 596 605, 1942
- 17 Bradshaw, H H The Fall in Blood Pressure During Spinal Anesthesia, *Ann Surg* 104 41, 1936
- 18 Herrick, J F, Essex, H E, and Baldes, E J Observations on the Blood Flow in the Femoral Artery in the Dog Eight to Thirty Four Months Following Lumbar Sympathectomy, *Proc Staff Meet, Mayo Clin* 7 711, 1932
- 19 Horton, B T, and Craig, W McK Evidence Shown in Roentgenograms of Changes in the Vascular Tree Following Experimental Sympathetic Ganglionectomy, *Arch Surg* 21 698, 1930
- 20 Maxson, L H Spinal Anesthesia, Philadelphia, 1938, J B Lippincott Company
- 21 Evans, C H Spinal Anesthesia, Principles and Technique, New York, 1929, Paul B Hoeber, Inc
- 22 Sarnoff, S J, and Arrowood, J G Differential Spinal Block, II The Reaction of Sudomotor Fibers (To be published)

Review of Recent Meetings

ANNUAL MEETING OF THE SOCIETY OF UNIVERSITY SURGEONS

NEW YORK, N Y , FEB 7-9, 1946

CLARENCE DENNIS, M D , MINNEAPOLIS, MINN

THE 1946 meeting of the Society of University Surgeons was held in New York, N Y , Feb 7, 8, and 9, 1946, members were guests of the surgical staff of the Columbia Presbyterian Medical Center. The group was welcomed by Dean Rappleye, who pointed out two challenges to be met by groups such as this. The first, that of surgical training for the returning servicemen, and the second, the maintenance of high surgical standards in the face of the prepayment medical plans shortly to be instituted.

Dr Whipple related his experiences in surgical extirpation of pancreatic cancers, with his conclusions on proper diagnostic and technical procedures. Dr Darrach discussed the history of the Lane technique in the plating of fractures and Dr Auchincloss spoke of Dupuytren's contraction. Dr St. John presented his much discussed data on the frequency of discovery of gastric malignancies in routine gastrointestinal roentgen studies of patients past 50 years of age (124 per 1,000). Dr Golden presented roentgen evidence that the occasional occurrence of vomiting after gastrectomy is due to marked temporary hypertonicity in the proximal and distal loops. Dr Canavarro presented some of the first statistically significant data to appear in support of early ambulation after surgery. In 500 cases, as compared to 500 controls, postoperative complications were cut in half by early ambulation, less medication was needed, patient morale was better, and savings in cost and hospital bed days resulted. Patients were made to walk within twenty four hours. Dr Richards presented results on catheterization of the heart via the basilic vein, with data on lesser circuit pressures in various cardiac and pulmonary diseases. Dr Humphreys presented a case of pulmonic stenosis improved by the Blalock operation. Dr McDonald presented a very convincing film on the use of heterologous skin grafts as temporary dressings in extensive burns. Dr Hanger presented a readily comprehensible arrangement of tests of liver function—one that seemed to simplify the problem to most members. Dr Seegal aroused much interest and speculation by her presentation of the isolation and antibiotic activity of protoanemonin, a derivative from buttercups, this agent is effective against *Bacillus coli* and the tubercle bacillus in doses well tolerated experimentally. Dr Frantz presented data on her absorbable gauze for hemostasis. Finally, Dr Parsons made a plea that returning members of the Armed Services keep their reserve commissions and otherwise retain an active interest in the medical departments to avoid repetition of errors of the early period of World War II.

During the afternoon of February 7, members of the Columbia Presbyterian staff presented further brief reports. Dr Moore presented reasons for quick aspiration of traumatic hemothorax without air replacement. Dr Haagensen showed statistics indicating education of both the public and the profession in the next step in reduction of breast cancer mortality. Dr Werner reported intravenous use of crystallized amino acids, and Dr McLaughlin discussed the use of removable wire sutures in tendon repairs. Experiences with thiouracil were recounted by Dr Elliott, 20 per cent of the patients in his series developed complications, but the drug seemed more valuable than iodine alone. Dr Maier dwelt on bronchogenic cysts and methods of diagnosis.

A series of demonstrations by members of the Columbia Presbyterian staff, Doctors Frantz, Meleney, Scudder, Murray, Howes, and Blakemore completed the sessions for the first day

Papers presented by visiting members of the Society are to be found elsewhere in this issue of SURGERY

The Columbia Presbyterian group left a very marked impression upon the members of the Society because of the quality and quantity of the investigative work being pursued there. From quite another vantage point the impression was equally marked, for in addition to the scheduled cocktail hour, the formal dinner at the Pennsylvania Hotel, and the excellent luncheons served to the guests, the group proved cordial hosts on every occasion throughout the meeting

Book Reviews

Plaster of Paris Technique By T B Quigley, M.D. Pp 107 New York, 1945, The Macmillan Company

This monograph is a well written manual dealing with the practical application of plaster casts. It is well illustrated with photographs which for the most part show the steps in the application of casts to the various parts of the body. The description of improvised methods of supporting patients for application of hip spicas and other casts is good and the methods are unique.

Since this is a manual designed to instruct those unfamiliar with the use of plaster and the application of casts, only a single, simple method is described in most cases. One might gain the impression that fracture tables and more conventional methods of applying casts are unnecessary and not needed.

As a whole the monograph is sufficiently complete and covers the necessary material well. It should find its place as a supplementary text in the medical student's library and as a manual for all interns, residents, and practitioners who must apply casts.

General and Plastic Surgery, With Emphasis on War Injuries By J Eastman Sheehan, M.D., Professor of Plastic Reparative Surgery, New York Polyclinic Medical School and Hospital. Pp 345, with 495 illustrations. New York, 1945, Paul B Hoeber, Inc. \$6.75

This brief text outlines a number of well known principles in the treatment of war wounds. The earlier chapters comment rather generally on the principles of wound excision, control of infection, and the various types of wounds resulting from war trauma.

The chapters on burns are quite brief. The illustrations throughout the book are almost entirely copied from other texts, particularly from Hamilton Bailey's writings.

The latter chapters deal with the regions of the body and describe a number of standard plastic procedures.

Fractures of the Jaws By Robert H Ivy M.D., DDS, F.A.C.S., and Lawrence Curtis, A.B., M.D., DDS, F.A.C.S., University of Pennsylvania. Ed 3. Pp 174, with 199 illustrations. Philadelphia, 1945, Lea & Febiger. \$4.50

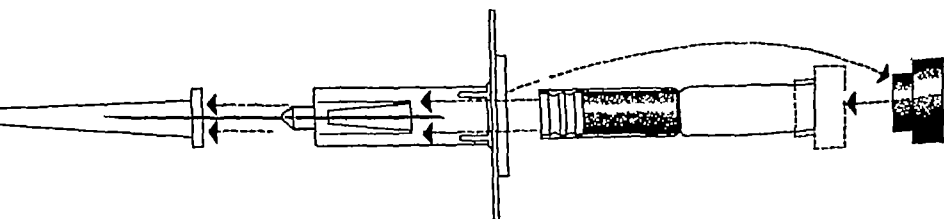
This, the third edition of this popular book, maintains the high standards set by the previous editions. The authors draw their material from a large experience with the subject and the excellent drawings and illustrations are nearly all from their own cases. The book is well written and the different types of fractures are dealt with clearly and concisely. There are, in addition, chapters on the Roentgenographic Technique and Dietary Management in Jaw Fractures. This book is a valuable contribution not only for the oral surgeon but for the general surgeon as well.

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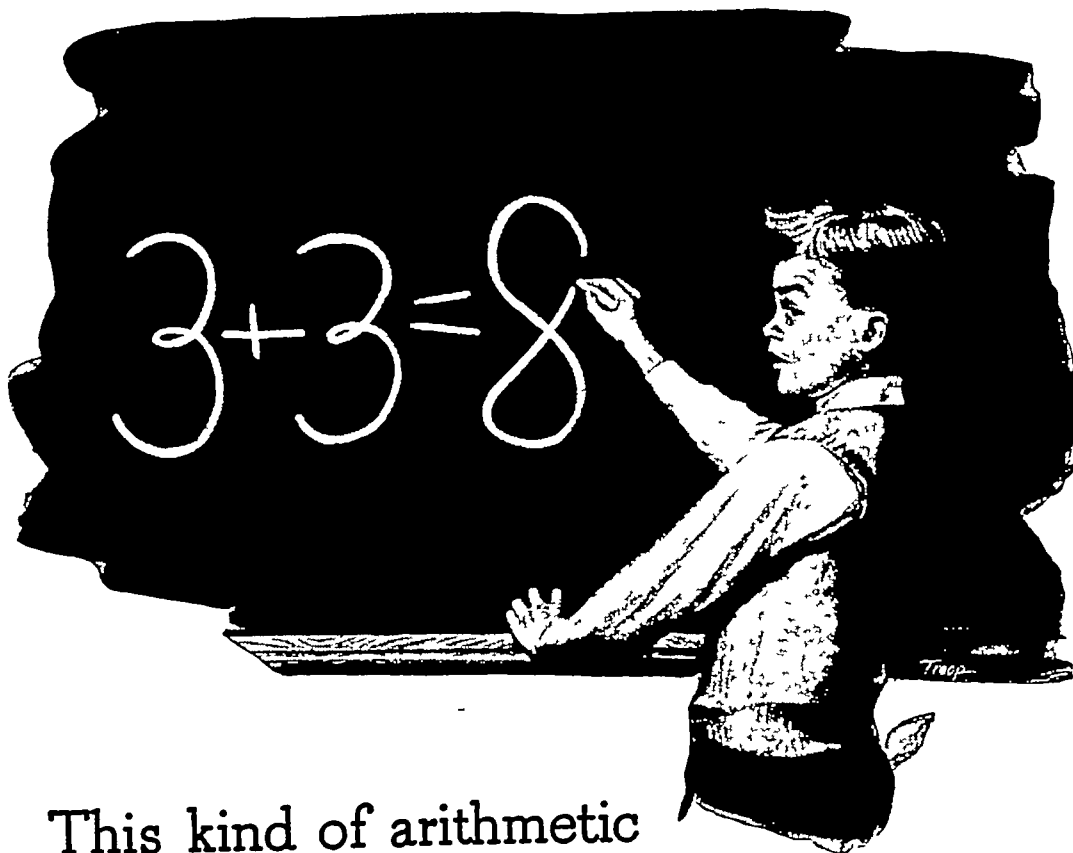
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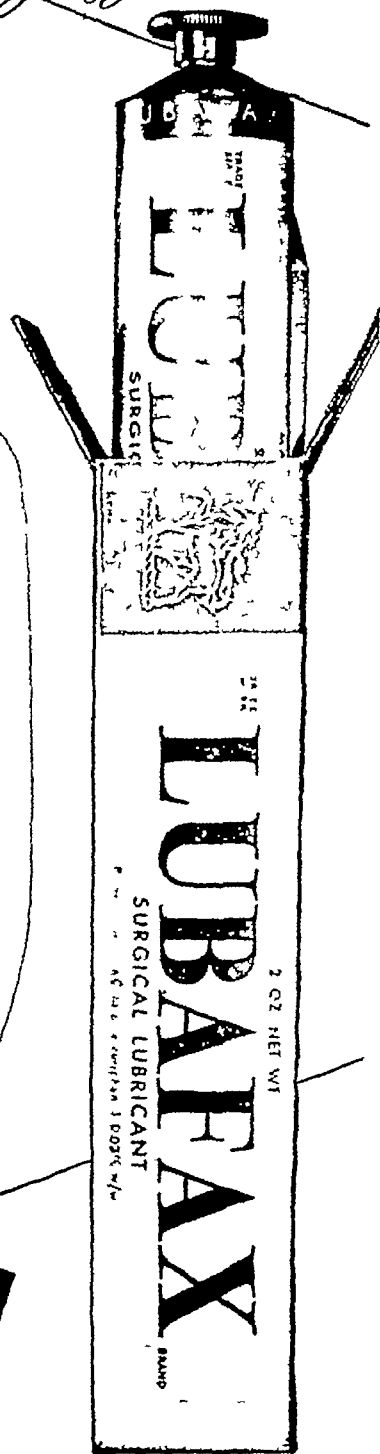
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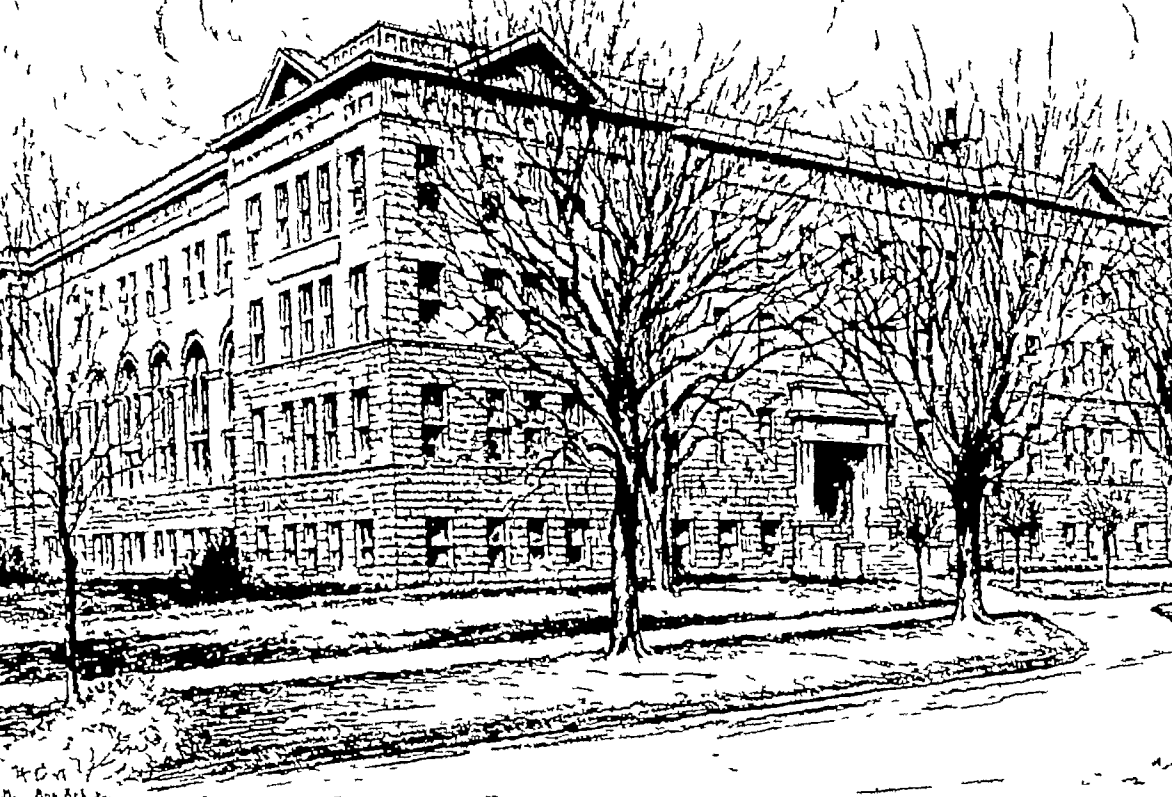
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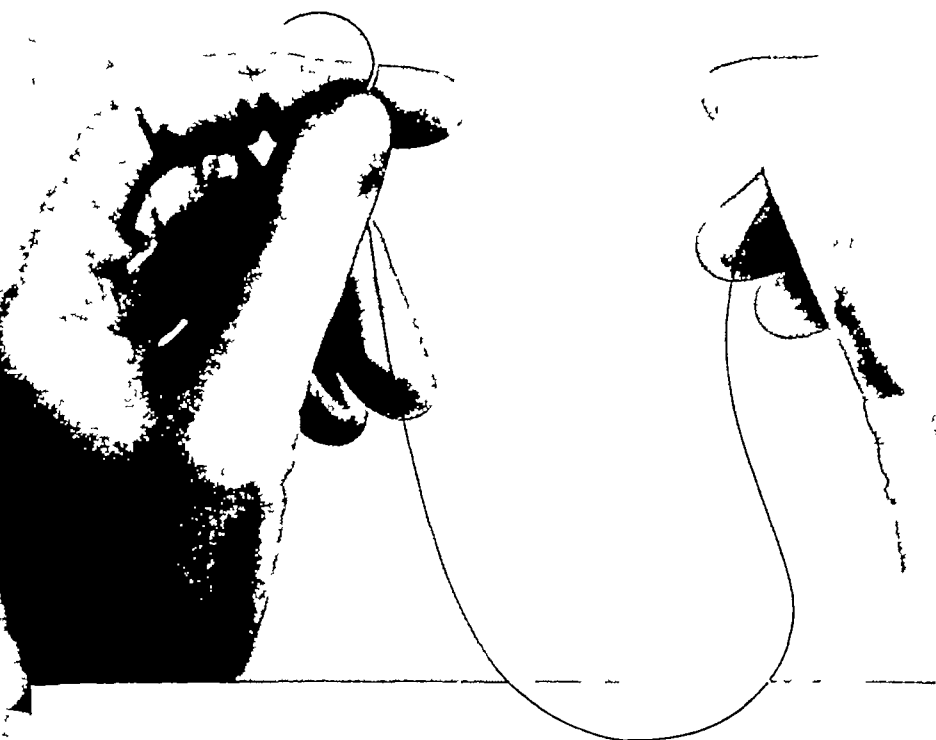
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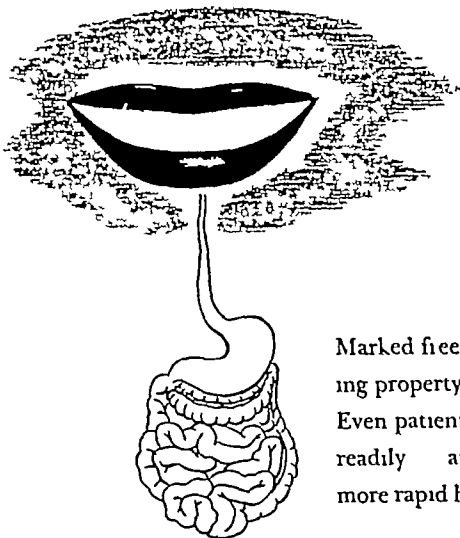
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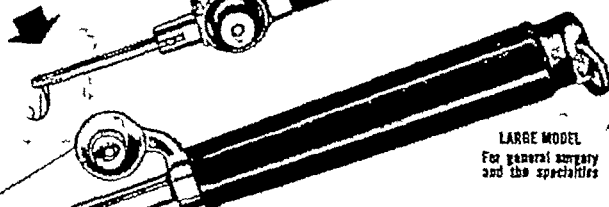
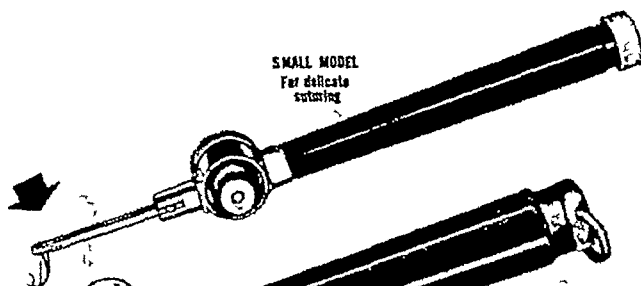
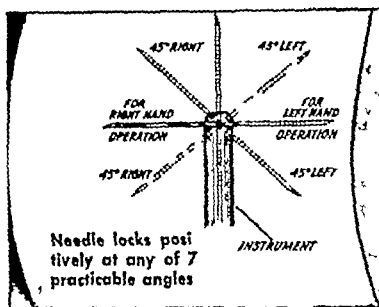
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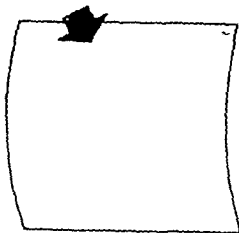
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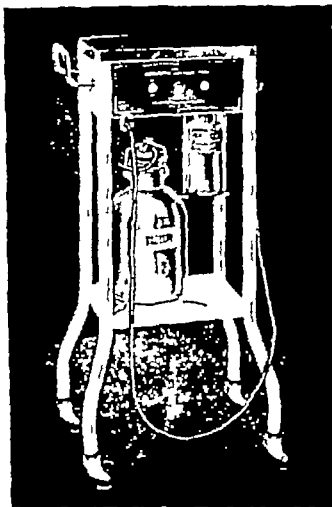
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Harvey Lecture, November 15, 1945

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Professor of Surgery and Director of the Department of Surgery, The Johns Hopkins University
and, Surgeon-in-Chief, The Johns Hopkins Hospital

A child of slightly less than two years of age had an oxygen content of arterial blood of 8.5 volumes per cent, a capacity of 18.0 volumes per cent, an arterial saturation of 33.3 per cent, and a normal red blood cell count and hematocrit reading. The condition was considered critical and operation was advised. After anesthesia was induced by the use of cyclopropane, the arterial blood pressure fell to 50/30 mm. Hg. An incision was made on the right side of the chest and the axillary vein was doubly ligated and divided. At this time the pulsations of the heart were very weak and barely visible. One half cubic centimeter of coramine was injected into the superior vena cava, and the pulsations of the heart became strong again. The right pulmonary artery was being freed of surrounding tissues when it was noted again that the action of the heart was poor. Coramine was injected into the right pulmonary artery. The pulsations of the heart improved, and it was decided that the operation should be terminated. The child's condition was unchanged after this exploration and a second operation was performed 12 days later. The previous incision was reopened. The innominate artery was shorter than usual, the subclavian artery was larger than usual, and it was decided to use this latter vessel for the anastomosis. When traction was made on the right pulmonary artery the pulsations of the heart practically ceased. Coramine was injected into the right pulmonary artery. It is doubtful whether the procedure could have been completed successfully if a side anastomosis had been performed. The child showed a dramatic improvement. Twelve days following the second operation the arterial oxygen content was 10.1 volumes per cent, the arterial capacity was 16.8 volumes per cent, and the arterial saturation was 63 per cent, with the preoperative figure of 33 per cent.

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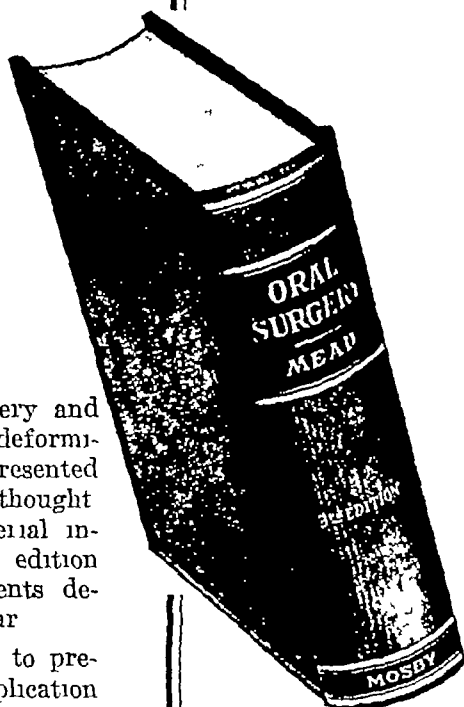
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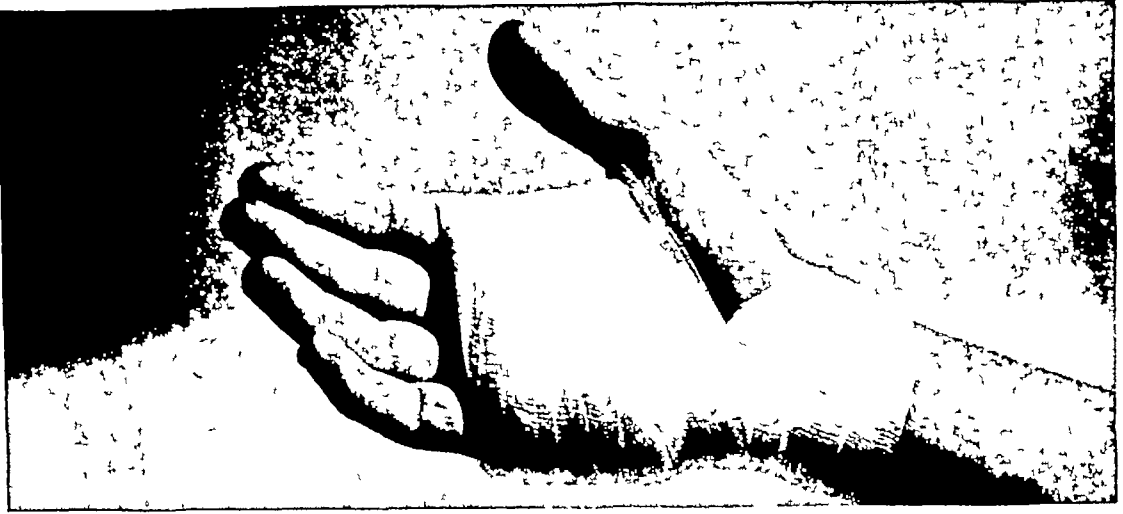
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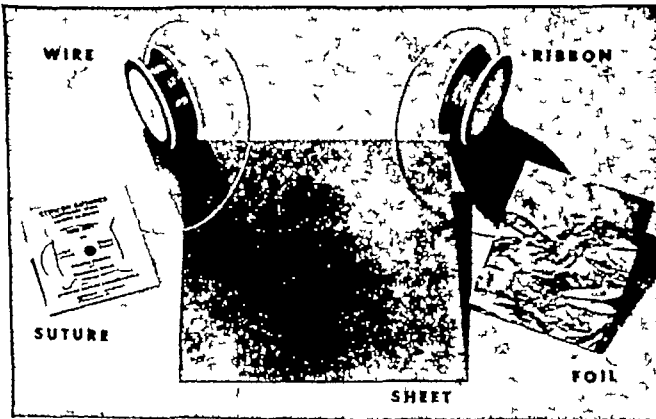
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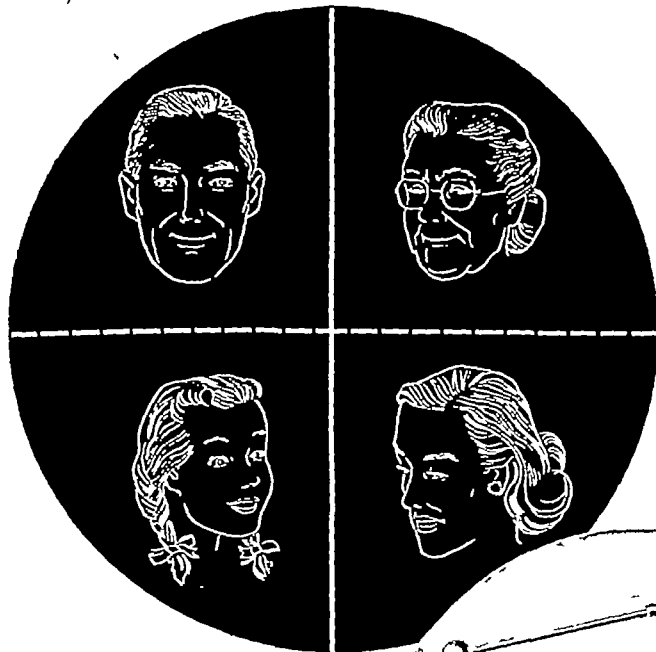
*Olson, C. T. "The Place of Tantalum in Surgery" *Industrial Medicine* 13:917 November 1944



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SURGERY

VOL 20

SEPTEMBER, 1946

No 3

Original Communications

TREATMENT OF EXTREMITIES FOLLOWING SUDDEN FAILURE OF CIRCULATION

GORDON MURRAY, M D, J S SIMPSON, M D, AND N A WATTERS, M D
TORONTO, CANADA

(From the Department of Surgery, University of Toronto, Toronto General Hospital)

THERE is much evidence to indicate that the orthodox method of treatment of acute failure of circulation such as occurs in embolism, diabetes, senile or Buerger's gangrene, or injuries to major blood vessels and frostbite,¹ might be revised to advantage. The textbook treatment of such conditions, namely, elevation, heat, and mild antiseptic dressings, is a survival of the past, antedating Harvey's discovery of circulation of the blood and the increased knowledge of physiologic principles. Sydenham's recordings of the practices of Hippocrates indicate that in 410 B C he used the methods just described. It is probably fair to assume that Hippocrates did not know the physiology of circulation as we know it. His object in treatment was to hasten the formation of the line of demarcation and to facilitate the natural separation of the gangrenous from the adjacent living tissue, and his principles of elevation, and application of heat and embalming herbs, which are the textbook methods of treatment today, were quite effective in precipitating a pregangrenous condition into frank gangrene with the result which he desired. With the present knowledge of physiology, it would seem that the application of rational principles might prevent the advance of a pregangrenous condition and might set up conditions which would favor a return of circulation and survival of the part.

Elevation—With impaired arterial flow into an extremity, elevation beyond the horizontal can easily set up conditions under which no blood may reach the periphery. This posture also empties the veins so that only the proximal capillaries of the extremity have any circulation passing through them. This is easily seen in cases of arterial embolism of the lower extremity. With the patient lying horizontally on the back, the toes and fore parts of the feet are elevated, and in the typical case are snow white in color while the thigh and leg regions, which are not elevated about the venous level of the trunk, are

TABLE I SERIES A HINDLIMB FREE, NO CAST

NUMBER	DATE OF OPERATION	WEIGHT (Kg)	SEX	OPERATOR	OPERATION NOTE	WOUND CONDITION	FIRST DAY WHEN LEG TEMPERATURE EQUAL	GANGRENE AND DAY OF APPEARANCE OF SIGNS						CONTRACTURE	CONDITION OF LEG IN 3 WK	AUTOPSY	BACTERIOLOGIC FINDINGS
								GANGRENE	CREPITATION	SWELLING	DISCOLORATION	ODOR	ULCERATION				
A 1	10/16/43	9	F	J S	Took 2 1/4 hr, repeated anesthetic	Slight infection	5	0							Contracture in 2 wk		
A 2	10/17/43	81	M	N W	Removed urine with syringe	Infection	6	0						0	Normal		
A 3	10/24/43	103	M	J S	Used left leg, removed urine	Infection		3	3	3	3	3	3			Gas gangrene—Bacilli seen in muscle sections	B. welchii and Staph aureus
A 4	10/24/43	10	M	N W	Usual—1 hr, 50 min	Infection	6	0						0	Normal		
A 5	10/31/43	8	M	J S	Removed urine, spleen large	No infection	4	0						0	Normal		
A 6	11/1/43	10	M	J S	No assistant, removed urine, 2 hr, 40 min, much blood loss	No infection	5	0						0	Normal		
A 7	11/4/43	78	M	N W	Removed urine	No infection		3	3	3	3	3	4			Gas gangrene	B. welchii and Streptococcus hemolyticus
A 8	11/7/43	65	F	N W	No assistant, removed urine	No infection	5	0						0	Normal		
A 9	11/14/43	107	F	N W	Removed urine, no assistant, breasts bled	No infection	4	0						0	Normal		
A 10	11/21/43	56	M	J S	Removed urine, extra anesthetic into femoral vein	Infected	5							0	Normal		

TABLE II SERIES B LIMB ELEVATED IN CAST

NUMBER	DATE OF OPERATION	WEIGHT (KG)	SEX	OPERATOR	OPERATION NOTE	WOUND CONDITION	FIRST DAY WHEN LEG TEMPERATURE EQUAL	GANGRENE AND DAY OF APPEARANCE OF SIGNS						CONTRACTURE	CONDITION OF LEG IN 3 WK	AUTOPSY	BACTERIOLOGIC FINDINGS
								GANGRENE	CREPITATION	SWELLING	DISCOLORATION	ODOR	ULCERATION				
B 1	12/19/43	62	F	N W	Removed urine	No infection		+	7	8	8	4	0			Gas gangrene, pressure sores	B. welchii and Staph aureus
B 2	12/20/43	56	F	J S	Clear fluid in peritoneal cavity	No infection		+	3	3	4	3	0			Gas gangrene	No growth
B 5	12/30/43	92	F	N W	Removed urine	No infection		+	6	6	6	6	9			Dry gangrene	B. welchii and col. in swab from ulcer
B 7	1/15/44	55	F	N W	Small incision, no urine removed, heavily padded cast	Infected, local		+			6					Gangrene, pus in foot	
B 8	1/23/44	74	F	J S		Infected, slight		+	6	7	6	6				Gas gangrene	B. welchii
B 10	1/29/44	108	F	J S	Removed urine, sulfathamide in wound	No infection		+					9	+		Gangrene, dry with sloughing	
B 11	2/6/44	7	F	N W	Usual, removed urine	Infected	8	0						0	Normal		
B 12	7/13/44	105	F	J S	Removed urine, left hypogastric not ligated	Infected	2	0						0	Normal		
B 13	10/19/44	10	F	N W	Closed with interrupted sutures	Infected		+	6	6	6	0	0			Gas gangrene	No clostridia
B 14	10/24/44	93	F	J S		No infection		+	14	0	0	0	14	0		Dry gangrene toes sloughed	

survive long periods of time as can be demonstrated by refrigeration of tissue cultures, skin grafts, and various other tissues. The degree of cooling must be controlled to avoid a level, below which oxygen interchange may be inhibited.

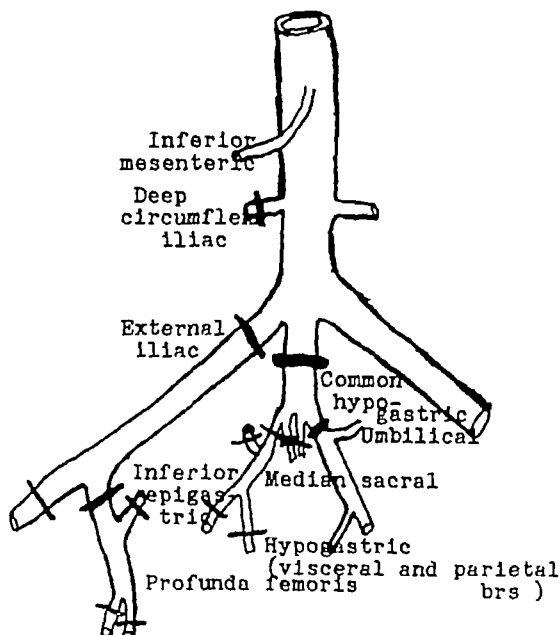


Fig 1—Indicating the sites of arterial ligation necessary to produce gangrene of an extremity of an animal

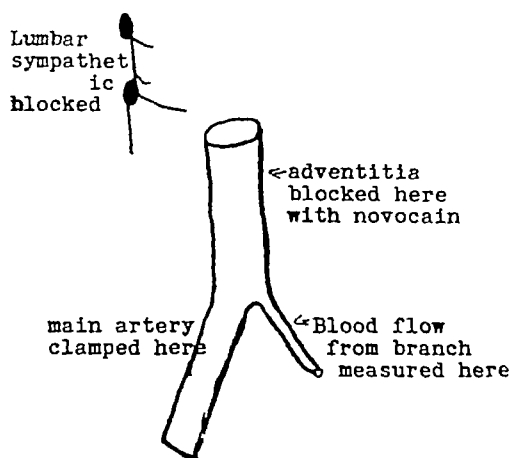


Fig 2—Schematic drawing indicating method by which the blood flow was determined and the sites at which nerve block was carried out.

Relaxation of Arterial Spasm—The application of heat to the trunk or other extremities is beneficial, causing reflex dilatation elsewhere in the vascular tree as demonstrated by the Landis and Gibbon⁴ test. Some direct attempts to produce dilatation of the vascular tree may be made by novocain block of the lumbar sympathetic trunk. Under some conditions this ganglionated trunk is

resected, thereby relaxing all vasoconstriction in vessels going to the lower extremity. In the upper extremity a similar attack may be made on the preganglionic fibers of the stellate ganglion.

Experiments have been done to show that lumbar novocain block or periarterial block causes an increased flow of blood through collateral vessels when the main artery is obstructed. To avoid conjecture necessary when using the thermocouple, dye-circulation time, and other means used for estimating blood flow experiments were done by measuring the amount of blood that poured from the end of a divided collateral vessel after blocking the main trunk. In Table III are shown samples of the effects of such experiments.

TABLE III BLOOD FLOW FROM DIVIDED COLLATERAL

EXPERIMENT NUMBER	MAIN ARTERY OPEN CONTROL (IN CC)	MAIN ARTERY CLAMPED (IN CC)	MAIN ARTERY CLAMPED, NOVOCAIN BLOCK OF ADVENTITIA (IN CC)
1	5	4	11
	8	5½	16½
	7½	4	15
2	9	10	18½
	8	9	19
	7	8½	20½

In forty-two such experiments similar results were obtained in all.

With proof that the flow through collaterals may increase from two-, three-, to fourfold in some cases, it is quite possible that the added flow provided by relaxing arterial spasm, under the conditions of dependency, and with a cool extremity, might tip the balance in favor of survival of the extremity.

The use of drugs such as alcohol and papaverine may be of some value in providing vasodilatation.

Four patients with sudden acute obstruction of main arterial trunks not suitable for surgical repair were treated in this way with most satisfactory results. In all these cases it was thought that from the nature of the accident and the obvious effect in the extremities, that high amputation was inevitable. Treated according to the principles enumerated, none of the extremities was lost. The maximum loss of tissue in any was a terminal phalanx of a toe and in some there was no loss of tissue. The extremities have all survived to be useful in walking.

CASE REPORTS

CASE 1—A P, aged 28 years, entered the hospital in August, 1941. This patient had an accident to the popliteal artery which caused complete occlusion. Within a few hours the fore part of the foot was white and the remainder of the leg below the knee was cyanotic and mottled when in the horizontal position. There was severe pain in the popliteal region extending halfway down the leg, with anesthesia and paralysis of all the muscles below the level of the knee. The anterior and posterior tibial arteries were not pulsating. The foot had an appearance very similar to that seen in embolism of the common femoral artery. When first seen at about six hours, it was considered that any operation on the popliteal vessels was not indicated because of the skin wound. There was grave doubt if the foot would survive.

Treatment—The patient was placed in a semireclining position with the foot dependent over the side of the bed. Cold, in the form of cotton covered ice bags, was applied to the foot and leg. Novocain block of the lumbar sympathetic chain was carried out. Within a few minutes the appearance changed. The foot, which had been white and shrunken, became bluish in color and slightly swollen. The coldness became less striking and within a few hours the leg to the level of the ankle was warm. The patient was nursed in this position for about three weeks. After four days some blisters appeared on the dorsum of the foot and toes and thus in itself was evidence that there was at least some circulation in the foot and toes. At the end of three weeks it was quite evident that the circulation was improving and that amputation could be avoided. Subsequently, the patient was able to walk quite satisfactorily on the foot and the circulation, now one and one half years later, is adequate although there is no palpable pulsation in peripheral vessels.

CASE 2—J K, aged 24 years, entered the hospital Oct 1, 1941. Following an operation for osteomyelitis of the superior ramus of the pubis, this patient within a few hours developed evidence of thrombosis of the femoral artery. The leg became cold to the upper third of the thigh. The foot was mottled and the toes were white. There were anesthesia and paralysis at the periphery. Pulsations in the femoral, popliteal, and anterior and posterior tibial vessels were absent. In the presence of an infected field, operation on the femoral vessel to remove the thrombus was contraindicated. The patient was put on treatment, hoping to avert a major disaster in the form of extensive gangrene of the extremity, which seemed inevitable. On treatment about to be described, the situation was improved considerably within a few hours and a very satisfactory end result was obtained. Gangrene to the level of the proximal phalanx of the great toe and of the tip of the second toe occurred. There were some spastic deformities in the form of a mild equinovarus resulting from poor posture during treatment. With correction of this, the patient was able to walk quite well on a foot which now has adequate circulation.

Treatment—Soon after it was apparent that the circulation was impaired, the foot and leg were placed in a dependent position. Cold was applied to the extremity, and the lumbar sympathetic chain was blocked with novocain. Within twenty four hours there was considerable swelling of the foot and even though it was cool it was not cold. Within seventy two hours there were some blisters on the dorsum of the foot. Both the blisters and the swelling were evidence that there was still circulation in the foot. (The foot that is gangrenous becomes desiccated if it is not suppurating.) From that time on there was evidence of some improvement of circulation of the foot and leg. The areas in the great and second toes already described began to show signs of desiccation and eventually turned black. Within a few weeks lines of demarcation were obvious and presently these portions of digits separated. The stumps healed. The result was most satisfactory in what appeared to be an extremely critical case of acute failure of circulation.

CASE 3—B K, aged 20 years, entered the hospital Nov 9, 1942. For about one year, following an injury, this patient had aching and pain in the left arm and forearm. For four months there had been stiffness of and inability to straighten the left arm. At this time it was noticed that the arm was blue and this involved the hand and finger tips. At other times the color would change to red and occasionally to a snowy white. This latter change could be initiated by elevating the hand above the head, but occasionally this blanching would occur with the arm in the dependent position. During the week preceding admission the changes in the hand became more striking with small areas of gangrene appearing at the tips of the index and middle fingers. There was intense pain in the hand during this time and so much stiffness that the hand was practically useless. The fingers, hand, and forearm were cold to the level of the elbow. There was no pulsation in the radial, ulnar, brachial, or axillary arteries. The subclavian artery was pulsating normally in the posterior triangle.

X rays of the cervical region showed a congenital anomaly of the left first rib. The second rib was normal in all respects. The first one was incompletely ossified and had an appearance similar to that of an incomplete cervical rib.

Operation—As it was considered that this might be a cervical rib syndrome, it was decided first to divide the scalenus anticus muscle. The operator who did this was impressed that the subclavian artery at this point was considerably compressed by a fairly massively developed muscle belly. He felt also that after division of the muscle the pressure was relieved. The vessel rolled downward and forward. Palpating with the finger through the incision it was demonstrated that the artery was pulsating proximal to this level but it was doubtful if there was any pulsation in the third portion of the subclavian artery.

In the forty eight hours following the operation it was apparent that the circulation to the extremity was still further impaired. There was some extension of the gangrenous processes and there was more pain, stiffness, and blueness at a higher level in the hand.

The brachial artery was exposed through a short incision, and was found to be not pulsating. There was marked edema of the wall of the vessel and of all surrounding structures. A needle was passed into the artery and no blood was obtained. A portion of the artery was removed for biopsy and was found filled with a thrombus.

It was decided following this that a resection of the central communications of the stellate ganglion should be carried out. This was accomplished through a posterior incision and at the same time the abnormal first rib was resected from its tubercle, anteriorly to its point of attachment to the second rib, within one half inch of the costochondral junction.

Following this operation the patient was placed in a position in bed, which would allow the arm to maintain a dependent posture, and cold in the form of ice bags was applied to the extremity. It was apparent within twenty four hours, that the circulation to the extremity was considerably improved. The blueness was replaced by a faint pink color. The pain in the arm was less severe and within a few days it disappeared completely. The gangrenous patches on the tips of the fingers showed signs of separating and within a few days they came off leaving healing surfaces. Within a short time the trophic changes in the nails were replaced by healthy growth of nails at their bases.

In this complete occlusion of the main arterial trunk, the operation had an important place in helping restore the circulation. The dependent position of the hand with the application of cold probably played an important role in preventing more loss of tissue.

CONCLUSIONS

In extremities with impaired circulation the best prospects for survival can be provided by keeping the extremity dependent, by the application of cold, and by using methods to effect maximum dilatation of the collateral vessels entering the extremities.

I am pleased to acknowledge the technical assistance of Mrs Cynthia Crookston and Mr W Cowan during these experiments.

REFERENCES

- 1 Murray, Gordon. Heparin in Surgical Treatment of Blood Vessels, *Arch Surg* 40 307 325, 1940
- 2 Murray, Gordon, Jaques, L B, Perrett, T S, and Best, C H. Heparin and the Thrombosis of Veins Following Injury, *SURGERY* 2 163, 1937
- 3 Allen, Frederick. Refrigeration Anesthesia for Limb Operations, *Anesthesiology* 4 12 16, 1943
- 4 Landis, E M, and Gibbon, J H, Jr. Vasodilatation in the Lower Extremities in Response to Emersion of Forearms in Warm Water, *J Clin Investigation* 11 1019 1036, 1932

GANGRENE FOLLOWING FRACTURE TREATED WITH HEPARIN, PAPAVERINE, AND INTERMITTENT VENOUS OCCLUSION

REPORT OF A CASE, REASONS FOR USING HEPARIN

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THERE is no record of impending gangrene following fracture having been treated with heparin. We report this case because a successful result was not expected in gangrene so far advanced, and because heparin may be useful in similar civilian and military trauma, such as paratrooper's landing injury. And there are several kinds of war wounds complicated by thrombosis, in the treatment of which amputation is done for imminent or existing gangrene. In the field, heparin may be administered by intermittent intravenous injection every four hours, the dose being from 50 to 75 mg.

CASE REPORT

N G, a man 44 years old, fell eight feet from a scaffolding to a concrete floor at 10 A M, May 21, 1943. Upon striking the floor in an upright position, his right foot struck some wood. The ankle turned abnormally, and he fell to the floor. He rose, but could not walk due to severe pain and immediate swelling of the right ankle. This accident occurred at Patterson Field of the Army Air Service Command near Dayton, Ohio. At the civilian dispensary there, x ray examination showed a T shaped, comminuted fracture of the tibia extending into the ankle joint. A hospital bed was not available, and for personal reasons, the patient chose to be transported by ambulance to Columbus, a distance of fifty five miles. He left the Field at 2 P M, and arrived at Grant Hospital, Columbus, at 4 20 P M. In transit, the foot and leg were supported by pillows.

Röntgenograms taken on admission to Grant Hospital showed slightly more displacement of the fragments. The ankle and foot were swollen, but there were no abrasions or lacerations of the skin. Due to continuation of the swelling, immobilization of the fracture was not done that evening. Ice packs were applied intermittently throughout the night. As the swelling increased, he suffered intense, throbbing pain which was eased with morphine. He stated that since the accident he had no sensation in the great right toe.

The next morning, May 22 at 8 30 A M, the fracture was immobilized in a circular plaster cast, extending from the base of the toes to the thigh. Immediately after the application of the cast, the plaster cut completely through to the wadding, throughout its length. In doing this, the surgeon made a cut in the anterior lower part of the leg (see Fig 14). This accident required widening of the split cast in order to arrest hemorrhage and to dress the wound, so the cast was not tight from the beginning. None of the three physicians present noted any cyanosis of the foot before the application of the cast. The procedure was done with a preliminary dose of morphine, gr $\frac{1}{6}$, and with ethyl chloride induction and light ether anesthesia. The patient was awake when he returned to his room at 9 A M.

The immobilization did not relieve the pain, for which he was given another dose of morphine, gr $\frac{1}{4}$, at 1 P M. At 4 P M the nurse noted that the toes of the right foot were very blue and cold, and he had apparently no sensation in the toes. The intern confirmed this observation and reported it to the surgeon, who ordered that the cast be spread open throughout its length. At 4 45 P M the circulation had not improved, and the cast was opened widely. At 6 P M the foot was still blue and cold. The patient was able to move the toes, but had no perception of ordinarily painful stimuli. The intern felt pulsation in the dorsalis pedis artery, but did not palpate the posterior tibial artery.

Although the cast no longer functioned as a circular, immobilizing splint, but only as a posterior support, the patient complained bitterly of increasing throbbing pain, with a burning sensation throughout the lower leg, ankle, and foot. At 11 P.M. another dose of morphine, gr $\frac{1}{4}$, was given. During the night hot water bottles and heat from an electric light tent were applied intermittently. This made the foot feel warmer to the examiner, but did not improve the color.

Throughout May 23 to 26, the patient complained of "tightness," a "tight band around my ankle," "burning sensation," "swelling," and "throbbing pain." He was given morphine, in $\frac{1}{4}$ gr doses, from four to seven times daily. On May 25 the plaster support was removed. The pulse and respirations were normal, but the temperature rose daily, to a high point of 102.6° F. on May 28.



Fig. 1A.—Oct. 10 1943 (five months after injury). Note loss of nails and deformity of all toes dorsal demarcation line across middle of dorsum and extending medially toward the heel (seen better in Fig. 2A). Tissues distal to this line are apparently still impaired. The mid-anterior lower leg scar resulted from the incision made when the plaster of the cast was cut.

On May 26 one of us (J. McL.) saw the patient for the first time. This examination revealed a greatly swollen ankle and foot*. The skin was thin and tight, and affected with fluid-filled vesicles varying in diameter from 1 to 5 cm. There was doubtless extensive deep hemorrhage. Palpation of the anterior and posterior tibial arteries gave no evidence of pulsation. The distal half of the foot was blue and cold, and the toes, particularly the great

*The injured foot and ankle appeared to be more than twice as large as the other foot and ankle. Measurements could not be taken due to the profusion of bullae.

toe, were the bluest and coldest part of the foot. A definite demarcation line was visible across the foot between the sole and the arch. This line extended posteriorly in the medial side of the arch (see Figs 1B and 2B). Between the arch and the heel, the area felt cool and had a dusky reddish color. Only the heel was felt to have and appeared to have normal circulation. These areas were visible on Oct 10, 1943, almost five months after the injury, and may be seen in the photographs taken on that date (Figs 1A, 1B, and 1C).

Pathology—Our concept of the pathologic condition was the following:

- 1 A T shaped fracture of the tibia extending into the ankle joint (Fig 1D)
- 2 Extensive hemorrhage into the ankle joint and surrounding tissues
- 3 Severe contusion of the foot, ankle, and lower leg, with tissue cell damage and exudate
- 4 Liberation of a large amount of thromboplastic substance (cephalin) from injured tissue cells and from blood cells and platelets, widely distributed in exudate and extravasated blood



Fig 1B—Oct 10 1943 (five months after injury). Note demarcation line between the sole and the arch of the plantar tissues which curves toward the heel on the medial side. Also notice nobby character and uneven texture of skin apparently covering nodules of subcutaneous tissue and very slow healing in toes most affected. Finally there is still a slight difference between the appearance of the skin of the arch and lateral half of the heel and that of the medial half of the heel.

5 Inadequate blood supply to all of the foot except the heel, with absence of the anterior and posterior tibial artery pulsation, possibly due to the following:

- (a) Deficient main artery circulation caused by pressure, thrombosis, thrombophlebitis, or laceration
- (b) Impaired collateral circulation caused by pressure in contused tissues
- (c) Vasoconstriction caused by the action of shed blood, or arterial muscle spasm due to nerve injury during the accident or consequent to thrombosis

6 Adhesions resulting from the precipitation of fibrin due to the conditions 2, 3, and 4 just stated.

Consideration of Treatment—1 In our opinion, the accidental cut (see Figs 1A and 2B) made in the anterior part of the leg during the splitting of the cast had not severed the anterior or posterior tibial artery, hence, vascular suture was not indicated.

2 Multiple deep incisions into the ankle to relieve the pressure on the main vessels was considered. This procedure might have been advantageous shortly after the accident, but 125 hours later, on May 26, the danger of introducing infection (and possibly gas gangrene) into devitalized tissues was too great in the presence of advanced circulatory gangrene. Surgical judgment dictated that it was judicious to leave alone that which was bad enough.

3 Dismissing the idea of surgical intervention, it was decided to try to improve the circulation by the use of heparin, papaverine hydrochloride, and the principle of intermittent venous occlusion*. The papaverine was used for its effect in relaxing striated muscle of vessels, and the intermittent venous occlusion for its mechanical aid to circulation. Heparin was administered for the reasons to be given. It was hoped that this triple therapy might stop the advancing gangrene, but reliance could not be placed on its effectiveness to prevent the threatened amputation.



Fig 1C—Oct 10 1943. Demarcation line curving medially toward heel. Loss of tissue of toes including nails. Abnormal shape of toes.

Reasons for Using Heparin—Heparin was used to increase the fluidity of the blood as an immediate aid to the main and collateral circulation. The effects of heparin tending to improve the circulation were these:

- 1 The decrease in the density and viscosity of plasma
- 2 The prevention of thrombus formation by platelets
- 3 The preservation of platelets from disintegrating to liberate the clotting substance, cephalin

* Lindgren and Wilander¹ reported a successful embolectomy for a 4½-day-old embolus with secondary thrombosis in the popliteal artery. The treatment of this patient included heparin, papaverine and the Pavex apparatus. Linton² reported a case of acute major occlusion in which gangrene of the foot was avoided by the use of intermittent venous occlusion.

- 4 The prevention of "stickiness" of platelets and red blood cells
- 5 Its effect in preventing adhesions which might cause impediments to the circulation by their pressure and constriction
- 6 Its effectiveness in prolonging the coagulation time, even after clotting has begun, and in maintaining hemorrhage and exudate in a more fluid and absorbable state
- 7 Its indirect effect in neutralizing the thromboplastic action of cephalin
- 8 Its effect in promptly reducing the swelling and impaired collateral circulation associated with thrombophlebitis and phlebothrombosis *



Fig 1D —Roentgenogram of fracture

- 9 Its effect in restoring circulation in vessels affected with thrombosis †

All of these effects of heparin are well known, and have been verified by many workers. The effect of increasing the fluidity of the blood was observed in the first (1916) preparation of this anticoagulant. Its effect in neutralizing the thromboplastic action of cephalin almost prevented its discovery.³ In 1924 the value of the action of heparin (heparphosphatid) ‡ in the prevention of experimental thrombosis and pulmonary embolism was first demonstrated.⁴

*In one case thrombophlebitis in the neck following incision of a tonsillar abscess caused such swelling and intense pressure on the trachea that an emergency tracheotomy had to be done to relieve the dyspnea and cyanosis. The swelling and pressure subsided only after heparinization.

†In another case phlebographs showed extensive obstruction due to a clot. Phlebographs taken two weeks after completion of heparinization showed re-establishment of circulation. These cases will be published.

‡Heparphosphatid (and cuorin) were renamed antiprothrombin (Howell, W. H. The Coagulation of the Blood. Harvey Lect. 1916-1917 Series 273-324 1917) and antiprothrombin was renamed heparin (Howell, W. H. and Holt, E. Two New Factors in Blood Coagulation. Heparin and Proantithrombin. Am J Physiol 47 328-341 1918).

Prognosis—Judging by previous clinical experience, it did not appear possible for recovery to occur in a foot which had lacked adequate circulation for a period of five days and five hours, or 125 hours. With gangrene in parts of the toes, advanced impending gangrene with cyanosis and coldness in the distal half of the foot, a distinct demarcation line and impaired circulation in all of the foot except the heel, we expected that in spite of the treatment outlined, the end result would be amputation below the knee. Written in the record is the notation "It is pretty late after the original injury to expect very much."

Treatment and Clinical Course—The apparatus for producing intermittent venous occlusion was operated for forty five minutes every four hours during the sixteen days from May 26 to June 11. The papaverine was administered from May 26 to June 2 in doses of $\frac{1}{4}$ gr every four hours at first, and later, every six hours. A total of $7\frac{1}{4}$ gr was given.

Heparin administration was started at 5 P M on May 26, and discontinued on June 2 at 9 15 A M. This is a period of 160 hours of heparinization, however, the needle came out of the vein several times. Due to lack of intern service, it could not always be reinserted promptly, and we estimate that five hours approximates the total time the intravenous drip was interrupted. During these periods the coagulation time was lowered, but did not arrive at the preheparinization coagulation time of three and one half minutes. At times the patient was irrational, and most of the time he was in an angry mood from pain. He made attempts to remove the needle from the vein of the right ankle, thus we could not tie a ball tipped cannula into the vein of the uninjured ankle.

Four ampules of heparin* solution (400 mg of heparin in 40 c c of saline solution) were added to 1,000 c c of Ringer's solution and administered at an average rate of about 25 drops a minute. The coagulation time desired (between fifteen and thirty minutes) was difficult to maintain. More heparin was used than is usually required to yield a clotting time between fifteen and thirty minutes. The patient received a total of $46\frac{1}{4}$ ampules of heparin solution, or 4.625 Gm of heparin administered in a total of 12,250 c c of normal saline and Ringer's solution—a daily intravenous fluid intake of 1,850 c c which did not produce edema. For the details of the administration of heparin and clotting times see Table I.

Progress—During May 27 and 28, the temperature continued to mount, and the patient was irrational at times, but he required much less morphine in spite of the discomfort caused by the various treatments. There was no definite visible improvement in the color or the temperature of the foot or ankle. On May 27 many of the bullae broke, so it was possible to secure a measurement at the level of the external malleolus, this being $13\frac{1}{2}$ inches. At the same level the left ankle measured $9\frac{3}{4}$ inches.

Throughout heparinization the sites of the broken bullae exuded dark, red fluid copiously, as though this fluid (heparinized?) percolated through the tissues from their depths to the surface. After heparinization stopped, oozing stopped, and the areas became epithelized promptly.

On May 29, after three days of this triple treatment, the toes appeared less cyanotic and felt warmer. The temperature receded gradually, arriving at normal on June 2. The ankle and foot were less swollen, the measurement being $1\frac{1}{2}$ inches less than previously. On May 30 further improvement was noted, the patient was no longer irrational and required very little morphine.

On May 31, all examiners agreed that the foot was definitely warmer and of much better color. Even the great toe, although almost black in color, felt warmer. One this day, May 31, at 2 30 P M hematuria was noted for the first time. This occurred after the administration of 3.5 Gm of heparin in about 112 hours. But as the temperature was steadily receding from its peak on May 28, as the swelling was subsiding, the pain lessening, and the circulation unmistakably improving, it was decided to continue heparinization, for it now appeared possible to avoid the threatened amputation of the foot, although the toes still seemed destined for death. Blood counts were taken to estimate the amount of blood lost in the urine.

On June 2 the pulse in the posterior tibial artery became palpable. The temperature became normal and remained there until the patient's discharge on July 17. The color of the

*Heparin is manufactured by the Hoffmann-La Roche Inc. Nutley, N. J. and is sold under the trade name of Liqueamin.

foot was almost "pink," and most of each toe was lighter in plum shade as contrasted with that of the previous bluish black color. The patient had very little discomfort and no more morphine was required.

The loss of blood in the urine was not severe. As the posterior tibial pulsation was definitely re-established and the condition of the foot and ankle so much better, the heparin

TABLE I. DETAILS OF HEPARIN ADMINISTRATION AND COAGULATION TIMES

1943	HOUR	HEPARIN SOLUTION	DROPS PER MINUTE	COAGULATION TIME (MINUTES)
May 26	5 00 P M	400 mg in 40 cc plus 1,000 cc saline	20	3½
	6 00 P M		30	8½
	7 00 P M		30	8
	9 00 P M		20	17
	12 00 Midnight		25	11½
May 27	3 00 A M		27	14½
	6 00 A M		20	16½
	6 30 A M	300 mg in 30 cc plus 750 cc saline		
	9 00 A M		30	18
	11 30 A M	400 mg in 40 cc plus 1,000 cc saline		
	12 00 Noon		37	19
	3 00 P M		32	30
	6 00 P M		22	42
	8 30 P M	200 mg in 20 cc plus 750 cc saline		
	9 00 P M	(added to 150 cc of pre- vious solution)		
	12 00 Midnight		20	30½
			20	19½
May 28	3 00 A M		25	10½
	6 00 A M		20	19½
	7 45 A M	200 mg in 20 cc plus 750 cc	20	
	9 00 A M		22	16½
	12 00 Noon		20	15
	3 00 P M		20	17½
	6 00 P M		20	7
	7 15 P M	300 mg in 30 cc saline plus 750 cc Ringer's	30	
	9 00 P M		35	5
	12 00 Midnight		32	15
May 29	2 15 A M	400 mg in 40 cc saline plus 750 cc Ringer's	25	
	3 00 A M		15	32½
	6 00 A M		15	26
	9 00 A M		15	17
	12 00 Noon		14	30
	3 00 P M		16	14
	5 00 P M	400 mg in 40 cc saline plus 1,000 cc Ringer's	16	
	6 00 P M		16	10½
	9 00 P M		25	35½
	12 00 Midnight		20	44½
May 30	3 00 A M		16	5
	6 00 A M		20	11
	9 00 A M		20	4½
	10 30 A M	400 mg in 40 cc saline plus 1,000 cc Ringer's	28	
	12 00 Noon		28	20½
	3 00 P M		16	18
	6 00 P M		22	7½
	9 00 P M		22	9
	12 00 Midnight		22	11

TABLE I—CONT'D

1943	HOUR	HEPARIN SOLUTION	DROPS PER MINUTE	COAGULATION TIME (MINUTES)
May 31	12 55 A M	400 mg in 40 c c saline plus 1,000 c c Ringer's	22	
	3 00 A M		22	34
	6 00 A M		18	12
	9 00 A M		18	7
	12 00 Noon		25	4
	3 00 P M		40	13
	5 50 P M	400 mg in 40 c c saline plus 1,000 c c Ringer's	40	
	6 00 P M		38	6
	9 00 P M		45	25
	12 00 Midnight		40	35
June 1	3 00 A M		30	26½
	3 40 A M	400 mg in 40 c c saline plus 1,000 c c Ringer's	30	
	6 00 A M		30	27
	9 00 A M	(Error in coagulation time technique)	25	?
	10 00 A M	(Coagulation time checked)	25	10
	12 00 Noon		24	15
	3 00 P M		22	9
	6 00 P M		25	8½
	7 10 P M	400 mg in 40 c c saline plus 1,000 c c Ringer's	40	
	9 00 P M		40	23
	12 00 Midnight		40	25
June 2	3 00 A M		40	29
	5 15 A M	400 mg in 40 c c saline plus 1,000 c c Ringer's	40	
	6 00 A M		40	21
	9 00 A M	Heparin discontinued	38	24
	12 00 Noon			6
	6 00 P M			3

and papaverine were discontinued on June 2. It would have been continued for a few more days if the hematuria had not occurred.

From June 2 to June 28 the condition slowly bettered. The toes which had seemed fated for mortification regained adequate circulation, except in certain distal areas which became more circumscribed and remained black in color.

On June 28 a sketch was made of the foot indicating these necrotic areas (see Figs 3 and 4) which proved to approximate the final result when compared with the photographs taken on Oct 10, 1943 (Figs 1A and 1B), and those taken on April 15, 1944 (Figs 2A and 2B). Dead black skin, with some necrotic subcutaneous tissue, was removed from the toes from time to time, and the last of the black toenails dropped off on June 10. None of the nails thereafter grew normally (see Figs 1A, 1C, and 2A).

On June 6, the patient sat up in bed, on June 14 he was on the hospital porch in a wheel chair, and on June 28 he walked with crutches and the aid of an orderly.

On July 4, bone was exposed at the tips of the second and fourth toes, but he lost only a spicule or so from these areas. He was discharged from the hospital on July 17 and returned to light work, as a supervisor, on Sept 20, 1943. Upon discharge, he had no sensation in the foot except in the heel. In September, he noted returning sensation in the lateral side of the foot—a tickling sensation when drawing on a sock. Figs 1B, 1C, 2A, and 2B show that the lateral side of the foot was less affected than the medial side, by the impaired circulation.

At a follow up examination on Oct 10, 1943, he had some sensation in all of the foot except the great toe. All of the nails were deformed. The ankle was still considerably swollen, but had surprisingly good function.

The patient was again examined April 9, 1944, and photographs taken on April 15, 1944 (Figs 2A and 2B). The demarcation line was still visible at this time. The foot was almost normal in size upon awakening in the mornings but increased considerably after he had been up for a while. The ankle, the site of the unreduced fracture still remained large. Sensation returned to the entire foot, including the great toe, in fact, the sensation was normal throughout and his reaction to "tickling" the foot was normal. He has worked every day since his first return to work on Sept 20, 1943. He drives his car daily for long distances, supervising work in near by cities, and walks without the aid of crutches or cane, although he has a large shoe for the affected foot. He feels that the condition is still improving, the swelling during the day is less, and he is well satisfied with the result.



Fig. 2A—April 15, 1944 (eleven months after the injury). Demarcation line persists with medial extension toward the heel. Tissues distal to it appear to be abnormal in form and nutrition. Epithelization of toes almost complete, but imperfect. Compare with Fig. 10 for size and shape of foot. Ankle still swollen.

DISCUSSION

Gangrene—We have reported the facts of the case. It is difficult not to include in this paper a statement concerning our utter surprise or astonishment in witnessing gradually returning viability in tissue affected with gangrene, imminent gangrene and impending gangrene.

We all judged, on May 26, after more than five days of severe inadequate blood circulation in most of the foot, that the end result would be amputation.

of the lower leg for gangrene of the foot, we gave the treatment with the hope, but not with the expectation, of obtaining the result recorded

This result has made us wonder how long tissue can be deprived of blood circulation sufficient to maintain normal viability and then recover, after administration of the treatment given. In general, clinical experience has shown that recovery cannot be expected after forty-eight hours lack of blood

This case also brings up the question of what are the physical and chemical changes associated with the three states which we described clinically in this case, namely, *gangrene* of the toes, *imminent gangrene* of the distal half of the foot limited proximally by a distinct line of demarcation on the plantar and dorsal surfaces, and an area of *impending gangrene* involving the rest of the foot (except the heel). We pictured the pathology as a combination of dry gangrene (arterial supply defect) and moist gangrene (venous thrombosis)



Fig 2B—April 15 1944 (eleven months after injury). Demarcation line with medial extension persists. Epithelization of toes is almost complete but crude. Note in distal tissues especially the toes, a 'budding' as if formed from cells which lived whereas others near by presumably died

If the definition of gangrene is tissue death, it is difficult to understand how the toes, particularly the great toe, is live tissue today. That profound changes of tissues of the distal half of the foot, and very profound changes in tissues of the toes—changes toward death, if not to death—occurred appears evident to us, first, from the clinical signs we saw and felt, and second from the state of the tissues one year after the injury, which is partly shown in the illustrations

If this distal half of the foot now appeared as normal as the other foot (shown for comparison) one might properly question our categories of gangrene, imminent gangrene and impending gangrene

That which we described as impending gangrene (the cool, livid colored arch, proximal to the demarcation line) apparently has regained normal circulation, temperature, and sensation, as has the distal half of the foot, but the skin of the distal half is not normal (as is shown in Figs 2A and 2B) and the demarcation line is still visible, although it no longer separates cyanotic from less cyanotic tissue

The toes may be observed in Figs 1A, 1B, 1C, 2A, and 2B and those of the injured right foot compared with those of the left foot. The loss or deformity of the nails is evident and is evidence of poor recovery of matrix cells from deficient nutrition, or evidence that some of the matrix cells did die and not enough survived to produce normal nails. But the profound changes approaching near death are perhaps best illustrated by the inability of the toes, even after a year since the accident and after six months of use in work, to regain their normal form, compared with the normal toes of the left foot. On May 26 and 27, the great toe, and parts of the other toes, seemed gangrenous in our opinion, that is, necrotic beyond the power of recovery



Fig 3

Figs 3 and 4—Dorsal and plantar views June 28 1943 (five weeks after injury, and twenty-six days after cessation of treatment) Drawings to indicate what was thought at that time would be the final tissue loss

If one argues that this is not true, that we were mistaken in our judgment of what was gangrenous, and that the only truly gangrenous tissue was that which finally remained black and was excised or dropped off, how does one account for the misshapen toes which might be said to appear as though formed by budding from nests of cells retaining sufficient vitality for mitosis—a sort of regeneration of the toe

And in clinical gangrene do all of the tissues (skin, subcutaneous tissue, vessels, nerves, and bone) die at once? The point we are trying to make is that even in clinical gangrene (as well as imminent and impending gangrene) there

is a point before all of the cells die at which treatment may restore the member, although in somewhat imperfect form

Perhaps the same principle is at work in the successful use of heparin in mesenteric thrombosis. The heparin can effect a release from imminent gangrene in the adjacent gut portions not excised

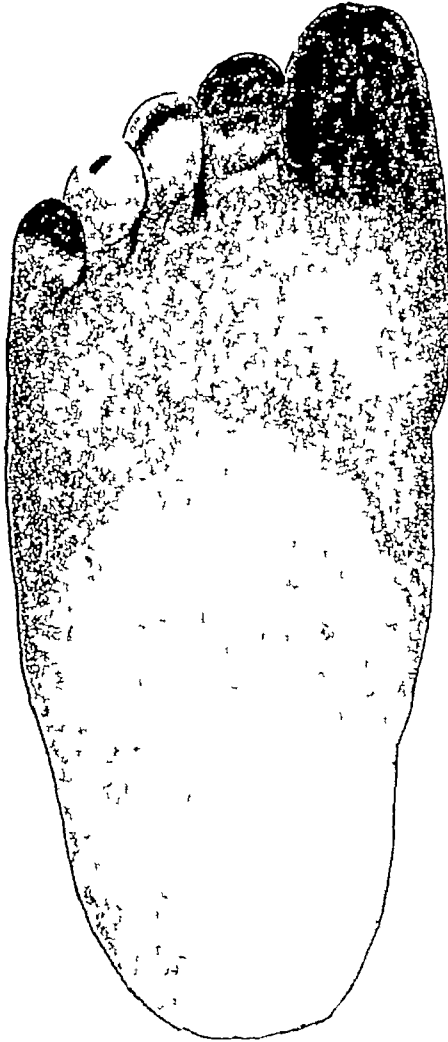


FIG 4

(For legend see opposite page)

This case, after more than five days of deficient circulation, and Lundgren and Wilander's case (embolus with secondary thrombosis) after four and one-half days, may cause us to revise our judgment on the possibility of recovery in gangrenous tissue caused by deficient blood circulation. Possibly animal experimentation could add to our knowledge on this subject

Adhesions — Another point which might be commented on here is the degree of function present in the ankle, foot, and toes. Considering the severity of the original injury, the untreated fracture into the ankle, the hemorrhage, the edema, and the tissue changes in the various degrees of gangrene, as well as the months of disuse, there is a remarkable freedom from crippling adhesions, the function of the ankle and foot being very good. This suggests that heparinization following various operations, the success of which is frequently cancelled by post-operative adhesions at the site of operation, may be of value. The results in such operations as nerve and tendon suture, reconstruction surgery in general, and certain orthopedic operations might be improved.

SUMMARY

A case is reported in which gangrene developed in the foot following trauma (including tibial fracture). Five days and seven hours after the injury, treatment by intermittent venous occlusion, papaverine, and heparin was begun, although at this time it appeared that amputation might be necessary eventually. The final tissue loss was small portions of the ends of the toes and all of the nails. Amputation was avoided and a satisfactory functioning foot obtained.

Recovery from clinical gangrene with this treatment is discussed, and it is suggested that heparin might be useful in preventing adhesions in certain reconstruction operations.

ADDENDUM

Aug 13, 1946. The patient has worked continuously since Sept 20, 1943, being on his feet most of the time. Swelling of the foot is worse at night, but he is able to wear a pair of shoes if the right foot shoe is made a little larger by stretching. There is still good function, with no late adhesions. He has no pain, and no skin ulcers have developed. He limps somewhat.

REFERENCES

- 1 Lindgren, S, and Wilander, O. The Use of Heparin in Vascular Surgery, *Acta med Scandinav* 107 148-160, 1941
- 2 Linton, Robert R. Peripheral Arterial Embolism, *New England J Med* 224 189, 1941
- 3 McLean, Jay. The Thromboplastic Action of Cephalin, *Am J Physiol* 41 250-257, 1916
- 4 Mason, E C. Blood Coagulation. The Production and Prevention of Experimental Thrombosis and Pulmonary Embolism, *Surg, Gynec & Obst* 39 421-428, 1924

HYDRONEPHROSIS

IV THE SURGICAL TREATMENT

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THE only cure of hydronephrosis is the removal of the obstruction causing it. The first principle in the treatment, therefore, is diagnosis. This means information not only of reality but of cause, degree, and complexity. The renal changes of back pressure may be on one side only or they may be bilateral. The obstruction to urinary flow may be in the upper or the lower part of the tract, even at the urethral meatus. The changes of back pressure then would have ascended progressively from below upward, affecting first the urethra, then the bladder, then one or both ureters, and finally the corresponding kidney or kidneys. In any case the hydronephrosis itself may be small or large and, if bilateral, very much alike on both sides or one side markedly different from the other in degree. Finally, the renal parenchyma in addition to hydronephrotic atrophy may be damaged by an acute, a chronic, or an atrophic pyelonephritis, or by something else, and the renal pelvis in addition to ectasis also may have infectious changes such as pyelitis cystica or other complication. The primary cause of urinary obstruction may produce changes elsewhere which in time add to the degree of the renal obstruction independently so that treatment must take into account these secondary factors in order to be effective. Clearly, a complete diagnosis is the first principle of treatment.

With diagnosis complete, sometimes no small accomplishment, the problem of treatment then presented may be so complex that the best judgment even of an expert may not solve it correctly. Occasionally noninterference is a wise decision. Usually there is a choice between doing one or more of several different things. Always the aim will be preservation of renal tissue with the least risk. Experience in failure and success has set up only a few general rules, each with exceptions.

The diagnosis discloses the following facts

I About the condition

- A The location, whether unilateral or bilateral
- B The degree, whether slight, moderate, or advanced
- C The complications

1 Renal

- (a) Infection, whether slight, chronic, or atrophic at this stage
- (b) Some other abnormality (1) of the hydronephrotic kidney, such as stone or tumor, etc., or (2) of its mate (which may even be absent)

2 Urogenital, coincidental, or related abnormality

II About the obstruction

- A Its location, whether the condition causing obstruction is infra-vesical or supravvesical
- B Its nature, whether extrinsic or intrinsic, and whether single or multiple
- C Its complications in the way of secondary changes of back pressure in other parts of the tract which have themselves now become obstructive, such as a vesical diverticulum or an elongated tortuous hydroureter, etc

At once one recognizes two types an insular hydronephrosis, an isolated pyelectasis and hydronephrotic atrophy of pure ureteropelvic origin, and a hydronephrosis similar pathologically but due to obstruction and accompanied by changes below the ureteropelvic junction

The treatment of the idiopathic unitary or essential type of hydronephrosis during the past twenty years has stimulated urologic ingenuity to the point that now the surgical methods of repair are almost perfect and many specialists confidently attempt the repair of any advanced hydronephrosis not completely functionless (see Deming) This point of view is vulnerable Why save a kidney which will always be an accessory of its mate, never capable alone of performing total function in the event that it would be called on by the loss of this mate to do so later? Death from renal insufficiency would be as certain as when nephrectomy had been performed originally instead of the repair The surgery may have been perfect but has added nothing to the future security of the patient If the surgeon determines beforehand, however, that an uninfected hydronephrotic kidney is capable of performing anything near one-fourth to one-fifth of total function and that after relief of the obstruction the renal parenchyma of the hydronephrotic kidney has reserve potentialities which would permit its renal units to hypertrophy upon stimulation as would happen when some disaster struck its compensatory mate (it might hypertrophy even to the degree of carrying total function efficiently with complete loss of its mate), then he has good reason to repair the hydronephrotic kidney and by so doing adds something to the future security of the patient This rule applies to the patient with an uncomplicated unilateral hydronephrosis, the opposite kidney never having been injured or diseased and being now compensatory Anything at all abnormal with it changes the problem This abnormality might better be corrected first If it also is hydronephrotic from a similar ureteropelvic obstruction but to a lesser degree, bilateral ureteropelvic repair may be indicated If bilateral, should the hydronephrosis of mild degree or the hydronephrosis of advanced degree be repaired first? Repair of the poor side first is the rule because (1) postoperative renal insufficiency and the danger of anuria will be less and (2) an optimal degree of repair of both kidneys will be secured Repair is hypertrophy in response to stimulation Therefore, after repair of the good side first, the poor side later might get little or no stimulation and the end result in renal reserve power would be much less than after repair of the poor side first, which would get its maximum stimulation and build up a reserve during the period of lessened function following the surgical repair of the good kidney

In the event of a decision to perform a bilateral repair, the second operation should not be delayed too long. Prolonged renal readjustment after the first repair, say, of the right kidney, might so alter the potentialities of the right and left kidneys as not only to lose the opportunity of an optimal degree of bilateral repair but even to make left nephrectomy preferable to a plastic repair of the left kidney.

Any surgeon who operates much learns that rules are controversial and not to be followed blindly, but he who reasons out his treatment of hydronephrosis in line with these arguments will prove his surgical judgment by better end results.

The decision for nephrectomy or plastic repair with unilateral hydronephrosis and for repair of the right or left side first with bilateral hydronephrosis does not end the play of surgical judgment (except with nephrectomy). The classification given in Table I of the repair methods in use with insular hydro-

TABLE I CLASSIFICATION OF PLASTIC REPAIR OPERATIONS OF HYDRONEPHROSIS

-
- | | |
|-----|---|
| I | Pelvioureterolysis |
| A | Simple pelvioureterolysis, with |
| 1 | Retrograde dilatation |
| 2 | Division of aberrant vessel |
| 3 | Partial pelvicotomy or pelvic plication |
| (a) | Kelly and Burnam |
| (b) | Young |
| II | Incision of the stenosis (when the obstruction has not been removed by pelvioureterolysis, as above) |
| A | Simple longitudinal incision, with |
| 1 | Closure after method of Heineke Mikulicz pyloroplasty (Fenger) |
| 2 | Double incision and closure of each after method of Heineke Mikulicz (Gibson) |
| 3 | Closure after method of Finney pyloroplasty |
| 4 | Closure after method of Trendelenburg pyloroplasty |
| (a) | Von Lichtenberg |
| (b) | Priestley |
| 5 | Closure with fat pad without suture (McIver) |
| 6 | The incision left open and allowed to heal over a splint |
| 7 | Combination of one of above and plication or partial pelvicotomy (Young) |
| B | Y incision, with |
| 1 | Oblique closure after method of Durante pyloroplasty (Schwyzer) |
| 2 | Long ureteropelvic anastomosis ("the inverted Y," Foley) |
| C | W incision (Ballenger—McDonald) |
| D | Longitudinal parallel incisions of the ureteral wall down to the mucosa at the site of the stenosis without suturing (Rammstedt) |
| III | Reimplantation of the ureter into the pelvis (when the insertion is high or when it seems wise to preserve the blood supply of the aberrant vessel) |
| A | After complete separation |
| 1 | Oblique anastomosis (Kuster) |
| 2 | Split anastomosis (Lubash) |
| 3 | Direct anastomosis |
| 4 | Pelvic anastomosis (Patch and Codnere) |
| 5 | Combination of one of above with plication or partial pelvicotomy (Priestley, Sargent) |
| B | Lateral (side to side) ureteropelvic anastomosis (Priestley) without separation |
| IV | Combination of one or more above methods, with |
| A. | Splint |
| B | Nephrostomy (or pyelostomy) |
| C | Nephropexy |
| D | Denervation |
-

nephrosis shows the very wide freedom of choice. No one of these methods can always be used to the best interest of the patient and any surgeon so limited by prejudice or preference shows poor judgment. Some conditions no doubt can be treated as well by any one of several different methods and a fixed preference for any particular one is then legitimate but other conditions might better be treated by other than any of these, therefore it is well to be familiar with all of the different methods.

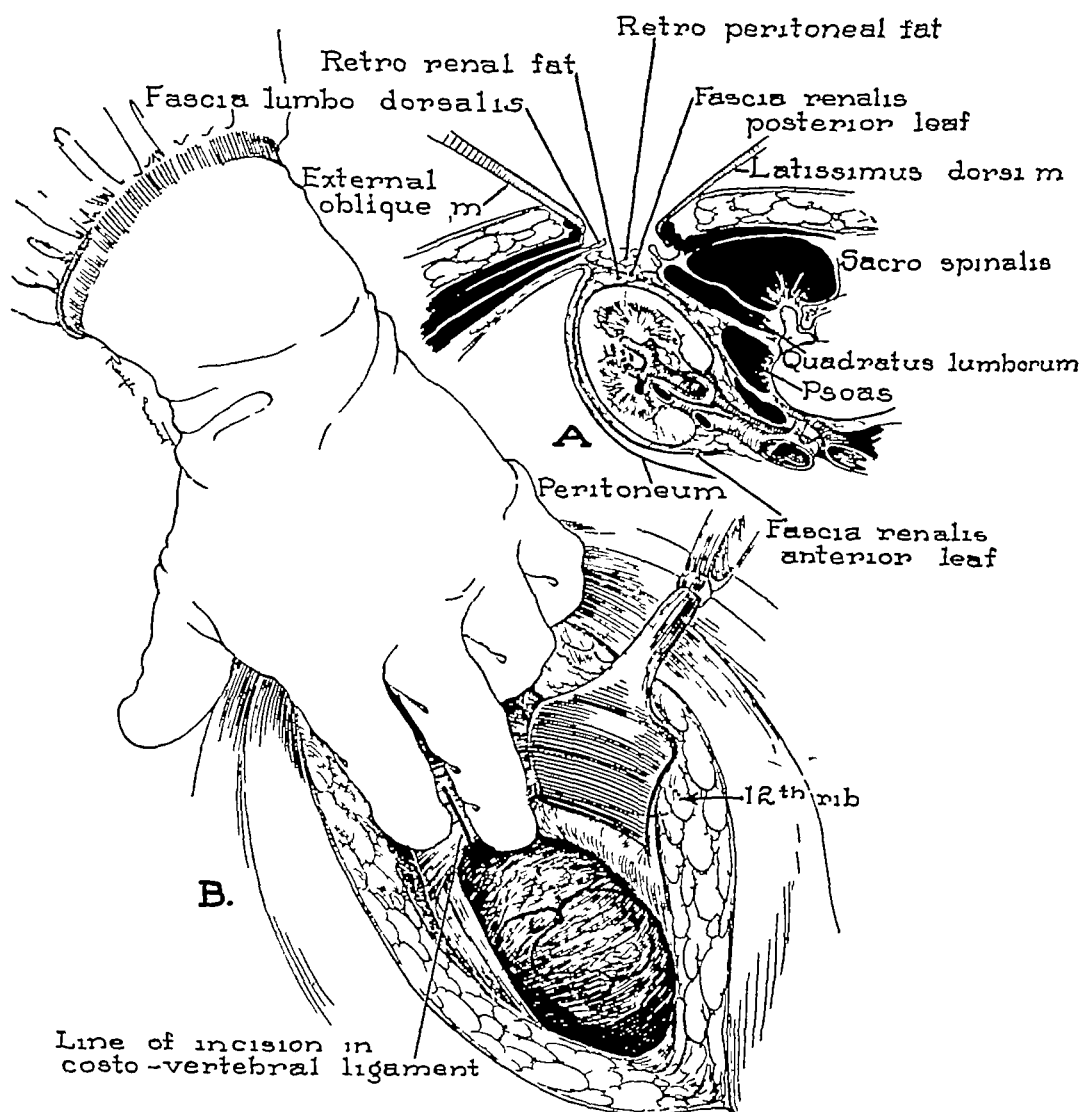


Fig 1—Exposure of the hydronephrotic kidney by an incision parallel to the twelfth rib. *A* The kidney freed first posteriorly along the line of cleavage between retroperitoneal fat and lumbar muscles (quadratus lumborum and psoas). *B* Division of the costovertebral ligament, care being taken that the pleura has been safely reflected back first, allowing the rib to be lifted (usually a snap is heard) giving adequate exposure.*

*All of the illustrations with the exceptions of Figures 22 and 23 have been drawn by Mr. Ralph Sweet and mostly on lines appearing in the literature modified as he has seen fit. Failure of acknowledgment of this free use of all papers to include other methods and references on this subject is not intentional.

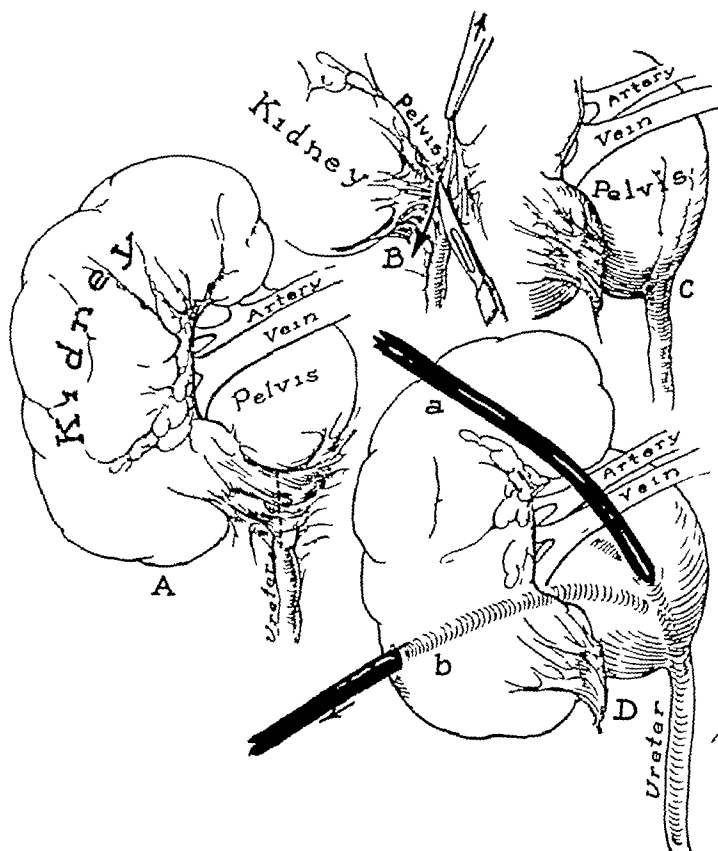


Fig 2—Simple pyeloureterolysis *A* The condition before dissection *B* Removal of bands and adhesions. *C* The obstruction removed satisfactorily *D* Two types of ureteral splint *a*, through the pelvis (used sometimes without nephrostomy or pyelostomy) *b*, through the kidney (always used with nephrostomy drainage)

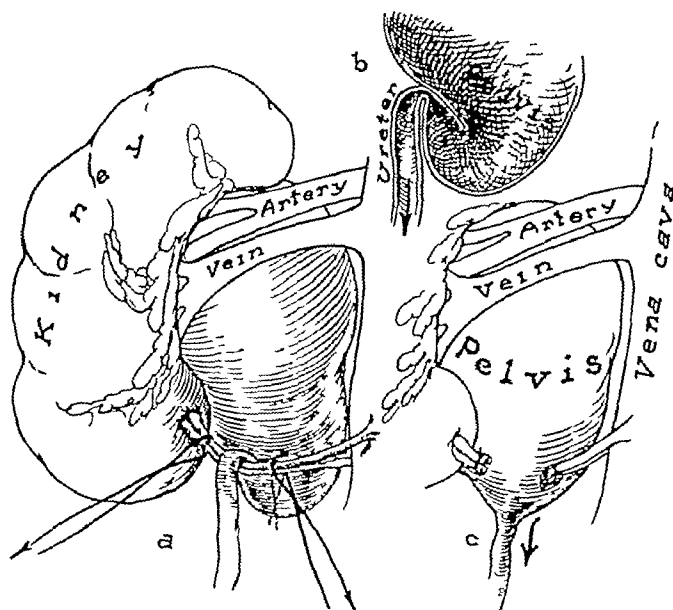


Fig 3—Pyeloureterolysis with division of aberrant vessel *a* The urinary obstruction of ureteral kink, *b*, caused by the vessel *c* The obstruction removed after the ureter has been straightened by division of the vessel

satisfactorily only after the kidney and ureter have been well exposed and the situation carefully studied

In exposing the kidney it is important that the line of cleavage be back of the retrorenal fat, leaving the quadratus lumborum and psoas muscles cleanly uncovered. The posterior surface of the kidney, cleaned down to its capsule, adheres firmly to these muscles later (Fig 1)

After exposure of the kidney and ureter as just outlined, a complex arrangement of veins and arteries in a mass of fat and fascia is usually found (Fig 2, A). This arrangement must be studied and carefully dissected out (Fig 2, B) so as thoroughly to free the ureteropelvic junction (shown in Fig 2, C). During this procedure one must decide for or against the preservation of any aberrant arteries, the veins are more or less unimportant. When it would seem

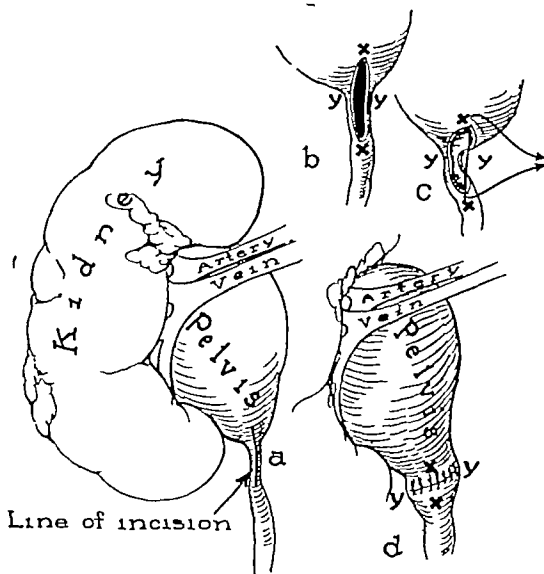


Fig 6—Simple incision with closure after the method of pyloroplasty of Heineke-Mikulicz (Fenger) a Line of incision b and c, method of closure x to x, d, dilatation secured

safe, division of the artery or arteries and pyeloureterolysis frequently removes the obstruction satisfactorily and the kidney then can be replaced in its new bed on the muscles and fixed there by some form of nephropexy if this would seem to be desirable. Usually it is advisable to splint the ureter either through the pelvis (pyelostomy) or, preferably, through the kidney itself with a nephrostomy tube (as shown in Fig 2, D, a, pyelostomy, b, nephrostomy). As a rule these tubes will hold the kidney in place until anchored by adhesions, obviating the need of intentional nephropexy.

The complete relief sometimes afforded by division of an aberrant vessel which kinks the ureter is shown in Fig 3.

It sometimes happens that even after complete pyeloureterolysis and division of the aberrant vessel there remains an unusual degree of pyelectasis which if untreated might harbor residual urine and prevent a cure even with a good

ureteropelvic opening. Such a condition is treated by partial pelvectomy (Fig 4, *a*, *b*, and *c*) or simply by pelvic plication (Fig 4, *d* and *e*). A modification of partial pelvectomy is shown in Fig 5 where an elliptical piece of the redundant pelvis is removed from both the anterior and posterior surfaces, reducing the pelvis to a normal size (shown in Fig 5, *a*, *b*, *d*, and *e*), after closure of each of these (as shown in Fig 5, *c*, *f*, and *g*).

When it is found after complete pyeloureterolysis and examination through an opened pelvis that the stenosis persists, then it is necessary to remove this obstruction, whether intrinsic or extrinsic, by some plastic procedure. The simplest one first proposed was to incise it longitudinally and close the incision after the method of a Heineke-Mikulicz pyloroplasty as shown in Fig 6, *a*, *b*, *c*,

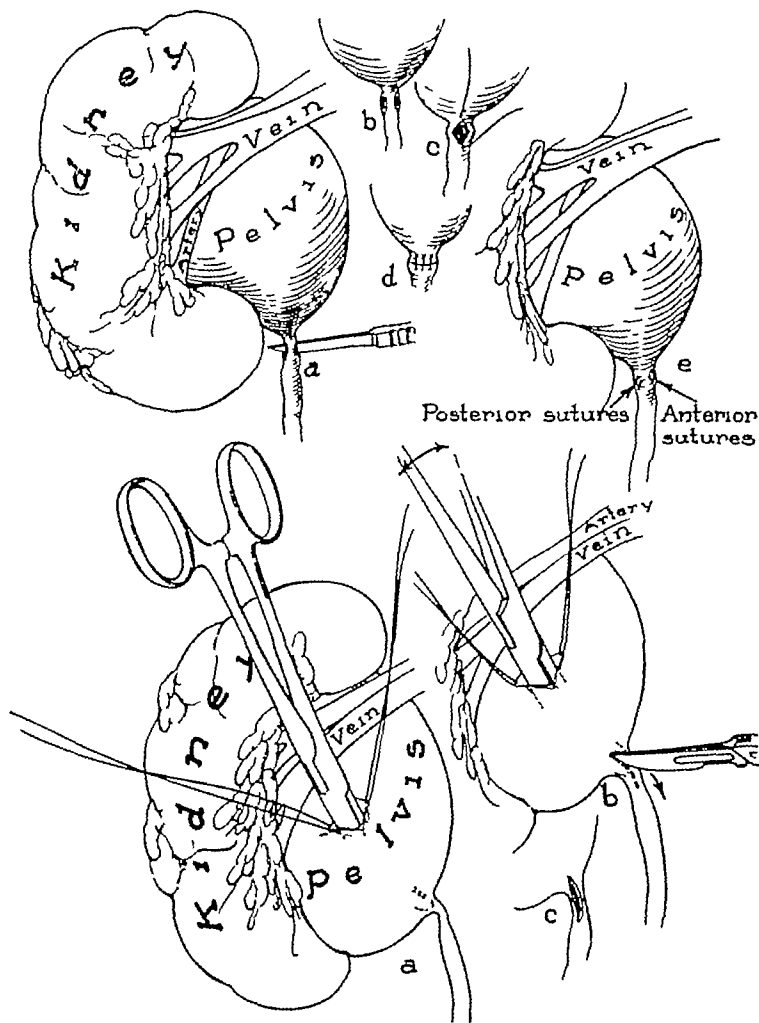


Fig 7—The longitudinal incision with closure after the method of Heineke-Mikulicz. The lower diagrams illustrate, *a*, the insertion of the tip of curved clamp through an opening in the pelvis into the area of constriction, *b*, the incision made upon the tip of this clamp as a guide, and *c*, the incision before closure. The upper diagram illustrates how a double incision *a* and *b*, with closure, *c* and *d*, will secure additional dilatation, *e* (Gibson).

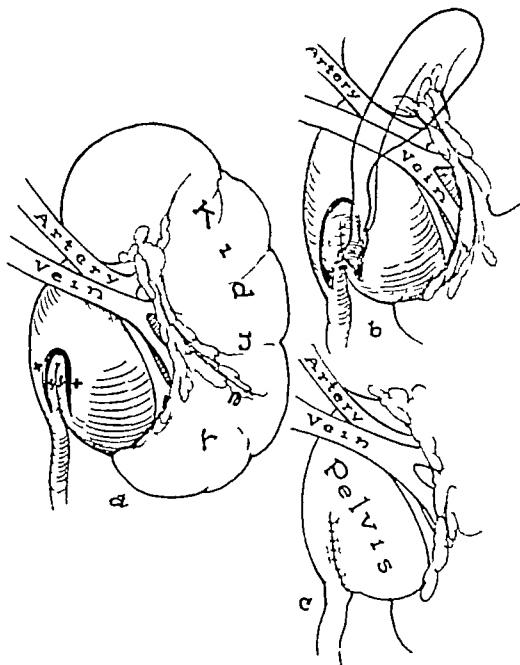


Fig 8—The curved incision with closure after the method of pyloroplasty of J M T Finney. *a* The incision showing how its edges are to be sutured together *y* to *y* and *x* to *x*, *b* the inside edges of ureter and pelvis being united *c* the outside edges closed

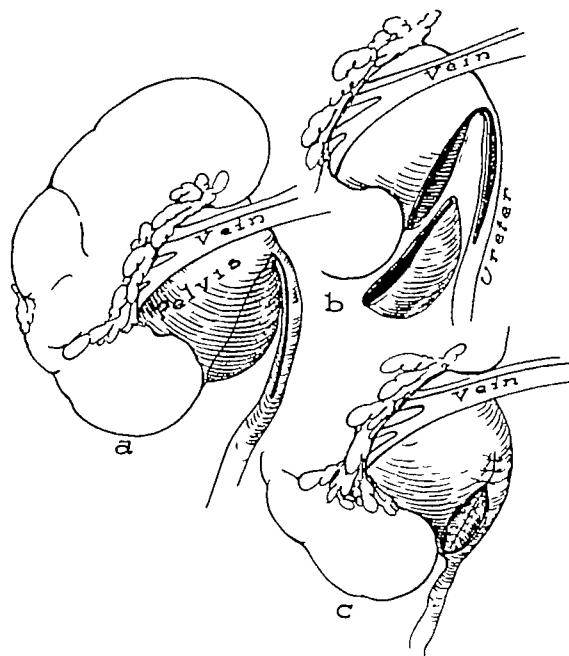


Fig 9—Ureteral incision and partial resection of the pelvis with anastomosis after the method of pyloroplasty of Trendelenburg (Von Lichtenberg Priestley). *a* The line of resection and incision *b* the opening afterward *c* the unobstructed orifice secured by closure of the two sides

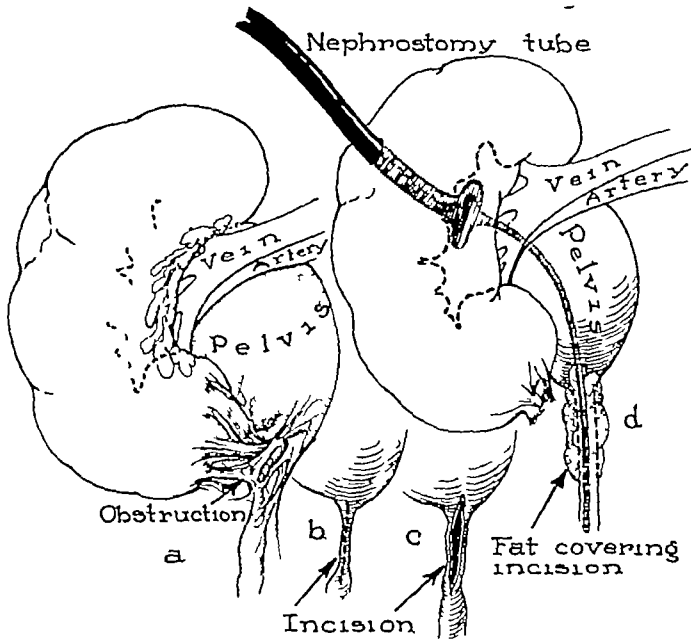


Fig 10—Simple incision with closure except for a covering of fat (McIver) a The condition before the ureter and pelvis have been freed, b the long line of incision of the constricted area, c relief of the obstruction by gaping of the wound d the gaping wound covered by a pad of fat and the ureter splinted with the nephrostomy tube—ureteral catheter combination

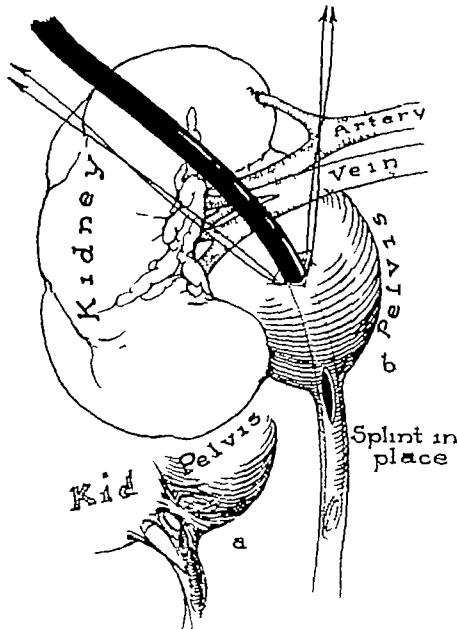


Fig 11—Simple incision of the area causing obstruction without closure a The mass of fibrous bands adhesions and vessels before pyeloureterolysis b Simple incision widening the obstructive area which is then kept dilated until healing has occurred by a splint here shown inserted through a pyelotomy

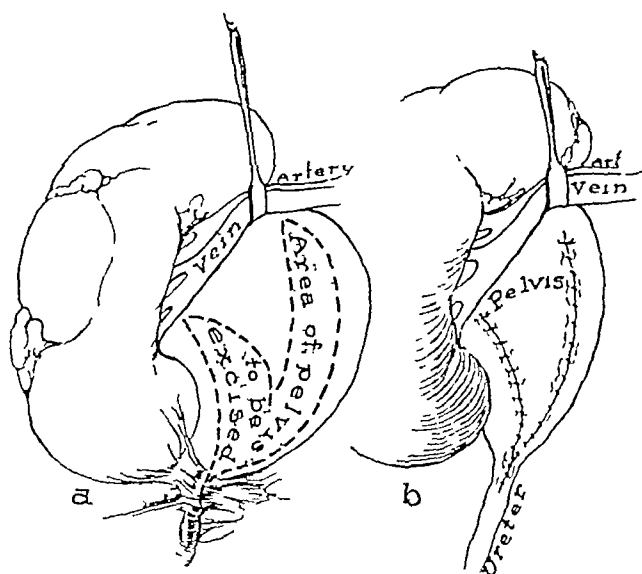


Fig 15—The W incision (Ballenger and McDonald) a Shaded area marking the portion of the pelvis to be removed by the W-like incision b The result after closure by interrupted sutures

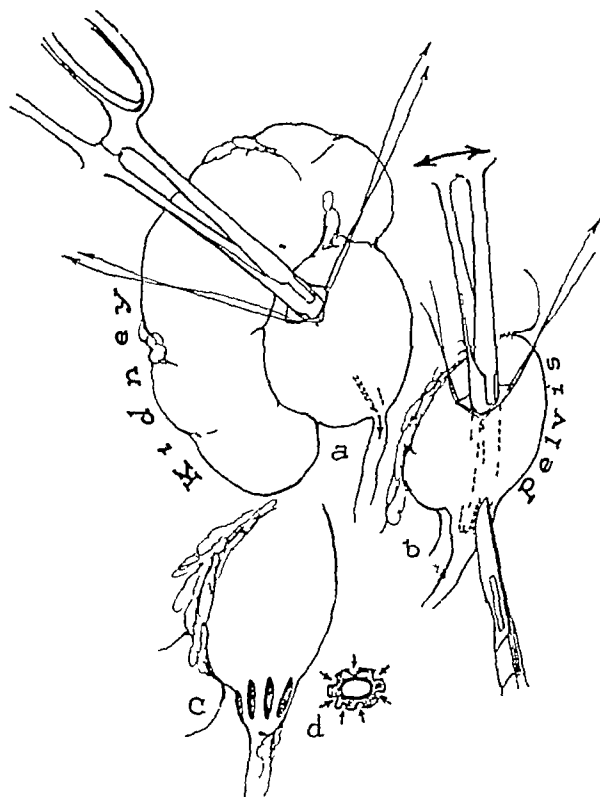


Fig 16—Multiple longitudinal incisions (Rammstedt) a The tip of a curved clamp is passed through an opening of the pelvis into the stenosed area b Multiple longitudinal incisions of the serosa and muscularis care being taken not to penetrate or injure the mucosa c and d The intact mucosa readily stretched to widen the lumen

of the area of the stenosis sometimes have been combined with methods of plication or partial pelvectomy (Fig 12), as has already been described and illustrated for the Tiendelenburg procedure illustrated in Fig 9

Another very satisfactory way of widening the ureteropelvic orifice is closure of it after Y incision, as shown in Fig 13, or better still as modified into a long inverted Y, as shown in Fig 14. With a rather redundant pelvis without much stenosis remaining after pyeloureterolysis, a double-armed incision somewhat in the shape of a W, as shown in Fig 15, has been proposed. Sometimes more satisfactory because so much simpler than any of these are multiple longitudinal incisions of the muscular layers at the site of the stenosis without penetration of the mucosa, as shown in Figure 16. Without suturing, these parallel cuts of the muscular coats act like pleats and thus produce a satisfactory enlargement of some stenosed areas.

When these two groups of procedures, simple pyeloureterolysis or this in combination with some form of incision and closure, fail to remedy the obstructive condition either because of the unusually high insertion of the ureter into the dilated pelvis or because the aberrant vessel is of such a size that it should be preserved, then several different methods of reimplantation of the ureter into a favorable site of the pelvis have been proposed, as illustrated in Fig 17. The ureter can even be anastomosed laterally as shown in Fig 18 without separation from the pelvis and any of the methods of reimplantation may be combined with plication or partial pelvectomy, as shown in Fig 19.

After the ureteropelvic obstruction has been removed by some one or more of the foregoing procedures, there arises the important problem of splinting the repaired area and of drainage, both intra- and extrarenal. There is some difference of opinion as to the advantage of a pyeloureteral splint, some advocating that it may lead to infection in a kidney which has heretofore been uninfected and for this reason is better omitted. Others believe that even in a clean case the ureter which has been satisfactorily enlarged and straightened, unless kept aligned in its new bed for a required period, may develop secondary adhesions which later on produce kinks and obstructions. As a rule, after a successful ureteroplasty the splint need not be left for any prolonged period, usually from seven to twelve days, and with the more efficient urinary antiseptics available the danger of any troublesome infection is negligible.

Many types of splints have been introduced. Those attached as an extension of a nephrostomy tube (Fig 20) have no particular advantage but do have the disadvantage that one cannot be removed without the other. Occasions arise when it is advisable to remove the nephrostomy tube or the splint first and leave the other for a time. Experience favors placing the ureteropelvic splint down the ureter and not retrograde (through the bladder). Ureteral catheters retained through the urethra and neck of the bladder occasion discomfort or give rise to infection which often complicate the postoperative care. Ureteral catheterization may become necessary, however, following the removal of the direct splint. With a dilated ureter the No 10 or 12 French urethral catheter, the closed tip of which has been cut off to leave an end

opening, will make a good splint. With a normal-sized ureter a ureteral catheter of not too large a size will prove satisfactory. In practically all of these cases direct drainage of the pelvis through the renal parenchyma is preferable to drainage through an opening of the pelvis. The pyelostomy tubes are likely to kink, cannot be replaced, and sometimes tend to dislodge the kidney from its direct contact with the muscles so that it does not become firmly adherent. On the other hand, a nephrostomy tube when properly placed can be removed and replaced at will. Furthermore, pyeloscopy through the opening is possible so that the repaired area can be dilated. The splint should be irrigated. A continuous drip irrigation with Suby's solution "G" or some similar antiseptic will largely obviate any of the risks of a complicating infection. Since irrigation is advantageous, the splint can be placed through the lumen of the nephrostomy tube, which is preferably of large caliber, perforating it at or near the lumbar skin surface, thus avoiding troublesome leakage (Fig 21).

There are many points in the placement of a nephrostomy tube which are important and which cannot be taken up in detail here. The opening into the pelvis should be made at a thin portion so that the least amount of parenchyma is damaged. It should be made retrograde and the tube later drawn through directly (Fig 21). It should be made at that portion of the kidney which will permit the tube to run in a straight course through the lumbar incision so that it will not pull the kidney away from its muscular contact nor be kinked when the kidney is replaced and, in addition, so that it can be removed and replaced at will. The bulb catheter has been largely used by others for nephrostomy drainage but it is excelled for this purpose by the cystotomy tube which has the direct open end and the right angle curve to fit the patient's side. The length of the arm of the tube should be chosen to best make this fit. There seems to be no particular difference in the time of renal closure after removal of the large tube as compared with that of a smaller bulb catheter. The nephrostomy tube without a bulb must be anchored to the kidney and to the lumbar wound by suture. A properly placed nephrostomy tube helps to pull the kidney into apposition with the exposed lumbar muscles and keeps it there until adherent so that intentional forms of nephropexy are unnecessary. Whether or not the pelvis has been closed tightly, retrorenal drains are always indicated. It is important that these drains be brought out the lumbar incision at its most dorsal position and away from the nephrostomy tube, not alongside it.

As a postoperative precaution, the patient should be kept on his back or permitted to lie only on the side operated upon so that the kidney will not be dislodged by its own weight.

Briefly then, the surgical treatment of insular hydronephrosis, if unilateral is a nephrectomy or some form of ureteropyeloplasty, if bilateral the latter for both as a rule and of the poorer side first. In doing this the kidney is freed, extrafascially posteriorly, intrafascially anteriorly, the renal capsule is intact. The ureteropelvic arrangement is studied and pyeloumeterolysis carefully performed. According to the result, the operator chooses, if necessary, one or more of the three types of procedures classified in Table I under I,

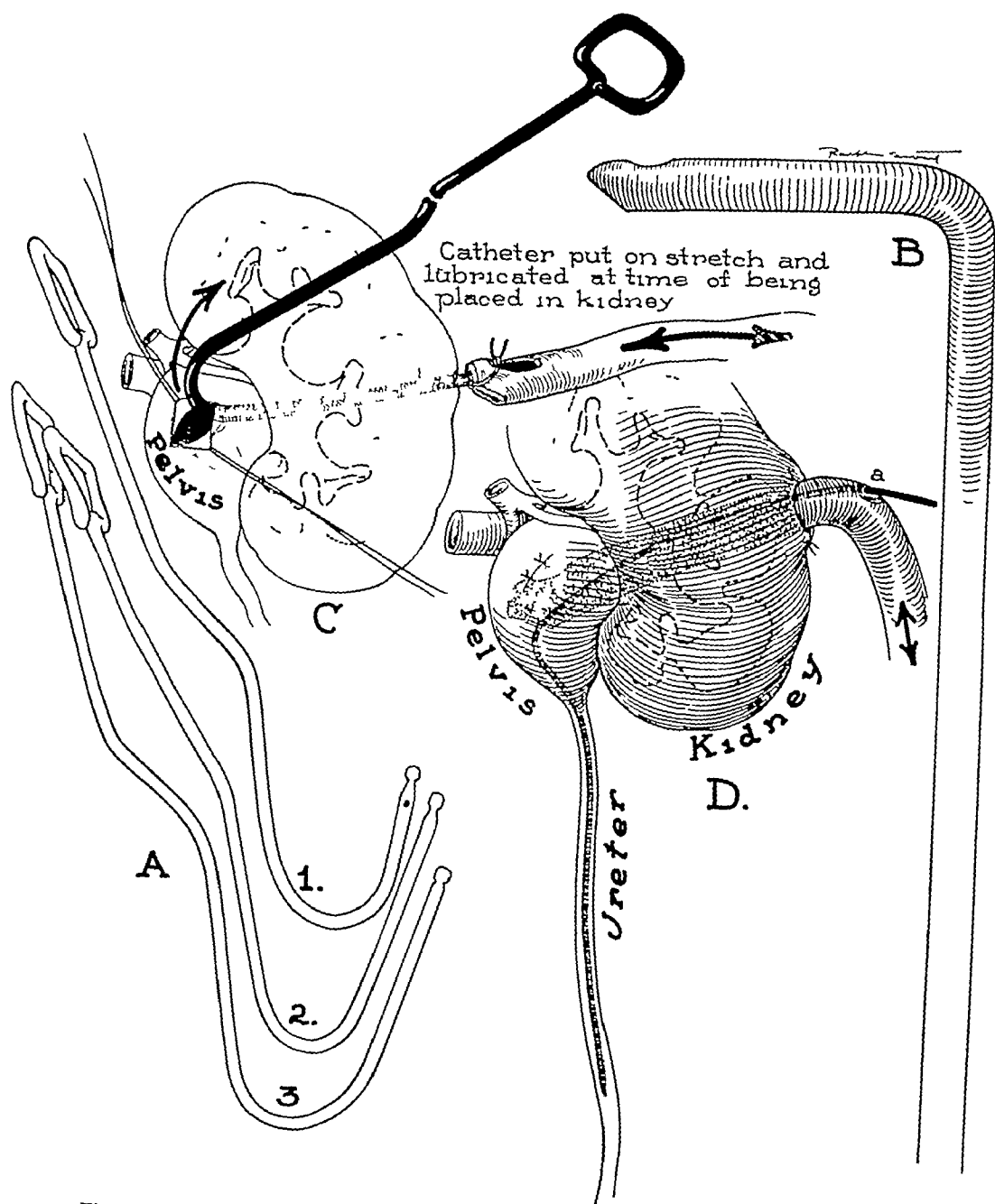


Fig 21—The nephrostomy tube and ureteral splint. **A** The metal guides of various sizes and shapes (1, 2, and 3) the one which is most suitable being selected. **B** The nephrostomy tube (angulated suprapubic drain). **C** The metal guide inserted retrograde through an opening in the pelvis with the tube (suprapubic drain) tied to its end by heavy silk suture. **D** Tube and splint in place. (The metal guide pulls the tip of the tube to the pelvic opening. The heavy silk tie is cut. The catheter-splint is passed down the tube through a slit in it at **a** and then threaded on down the ureter through the opening of the pelvis which is then closed as shown here by two interrupted sutures.)

valve removes the primary obstruction but few of these boys live long afterward, most of them dying eventually of renal insufficiency. In female infants and children, similar back pressure changes in the ureters and kidneys are seen without any known or discoverable cause of primary obstruction (Fig 23). In either of the foregoing cases hydronephrotic kidneys, uninfected or only mildly so, will undergo considerable repair with return of renal sufficiency after nephrostomy or a plastic operation on the ureter by which the elongated tortuous ureter is shortened and straightened out so as not to be obstructive secondarily.

The dilatation in both conditions is mostly ureteral and pelvic, little calyceal. Total renal function sometimes is fairly good, but persistence of infection is the rule in spite of the best known therapy by mouth or by uretero-pelvic lavage, and progressive atrophic pyelonephritis leads eventually to death from renal insufficiency. A plastic operation on these hydroureters is indicated only when previous tests not only have demonstrated considerable renal reserve but have given reasonable assurance that urinary infection can be controlled.

CONCLUSION

The surgical treatment of hydronephrosis varies with the condition. When unilateral of ureteropelvic origin, the choice of treatment is between nephrectomy and a plastic repair of the obstruction. When the relative function of the hydronephrotic side is less than one-fifth of the total, and the opposite kidney is healthy and compensatory, nephrectomy is in order. The repair of those hydronephrotic kidneys more capable than one-fifth of total follows three types of surgical procedures. Pyeloureterolysis may relieve the condition. When this fails to remove the obstruction, the ureteral narrowing may be enlarged by one of various methods of incision and closure, and when this would seem inadequate several methods of reimplantation of the ureter into its pelvis are available.

In bilateral hydronephroses of ureteropelvic origin, only a functionless kidney ever is removed. In bilateral repair, the poorer side should be done first and even when equally hydronephrotic, too long an interval should not elapse before repairing the second side.

In hydronephroses from obstructions below the ureteropelvic juncture (stone, prostate, stricture, etc.), removal of the obstruction usually suffices. Acquired changes of back pressure such as a diverticulum or tortuous ureter, however, may be obstructive and require treatment.

REFERENCES

- Ballenger, E. G., and McDonald, H. P. Conservation of the Hydronephrotic Kidney, *J Urol* 47: 203-208, 1942.
- Deming, C. L. Ureteropelvic Obstruction Due to Extrinsic and Intrinsic Lesions of the Ureter as a Clinical Entity and Its Treatment, *J Urol* 50: 420-431, 1943.
- Fenger, C. Operation for the Relief of Valve Formation and Stricture of the Ureter in Hydronephrosis and Pyonephrosis, *J A M A* 22: 335-343, 1894.
- Idem. The Collected Works of Christian Fenger, Vol. 2, Philadelphia and London, 1912, W. B. Saunders Company, pp. 687-704.
- Foley, F. E. B. A New Plastic Operation for Stricture at the Uretero-pelvic Junction, Report of 20 Operations, *J Urol* 38: 643-672, 1937.

- Gibson, T E Hydronephrosis Standardization of Surgical Treatment, New England J Med 222 910 917, 1940
- Hinman, F Obstructive Hydro ureteral Angularity With Hydronephrosis in Children, Arch Surg 18 (Part I) 21 58, 1929
- Idem The Treatment of Hydronephrosis, Southwestern Med 26 357 368, 1942
- Kelly, H A, and Burnam, C F Diseases of the Kidneys, Ureters, and Bladder, Vol 1, chapter 17, New York, 1922, D Appleton & Co
- Kuster, E Ein Fall von Resection des Ureter, Arch f klin Chir 44 850 854, 1892
- Lubash, S Uretero pyeloneostomy for Hydronephrosis, a New Operative Technique, J Urol. 34 222 229, 1935
- Lubash, S, and Madrid, A Uretero pyeloneostomy for Hydronephrosis, With Case and Experimental Reports, J Urol 38 634 642, 1937
- McIver, R. B Plastic Surgery of the Renal Pelvis, J Urol 42 1069 1083, 1939
- Patch, F S, and Codnere, J T The Treatment of Hydronephrosis Secondary to Aberrant Renal Vessels, Canad M A J 45 495 499, 1941
- Priestley, J T The Conservative Surgical Treatment of Non calculous Hydronephrosis, Surg, Gynec & Obst 68 832 841, 1939
- Sargent, J C Basic Principles Governing Conservative Surgery in Hydronephrosis, J Urol. 47 323 343, 1942
- Schwytzer, A A New Pyelo ureteral Plastic for Hydronephrosis, S Clin North America 3 1441 1448, 1923
- Von Lichtenberg, A Plastic Surgery of the Renal Pelvis and Ureter, J A. M A 93 1706 1708, 1929
- Young, H H Obstructions to the Ureter Produced by Aberrant Blood Vessels, A Plastic Repair Without Ligation of Vessels or Transplantation of Ureters, Surg, Gynec. & Obst 54 26 38, 1932

A METHOD FOR THE CHEMICAL PRODUCTION OF A PROLONGED SYMPATHETIC PARALYSIS

REPORT OF ITS USE IN TWO PATIENTS WITH CAUSALGIA

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OUR recent acquisition of a small quantity of a slowly absorbed local anesthetic agent (Rectocaine*) suggested the possibility of increasing the effectiveness of paravertebral injections in the treatment of causalgia by prolonging the resultant sympathetic paralysis. Cases 1 and 2 are reported to indicate the desirability of further investigation of this procedure in various conditions in which temporary sympathetic denervation is indicated.

CASE REPORTS

CASE 1—A 31 year old Chinese soldier sustained a perforating bullet wound of the left shoulder on March 13, 1945, which produced a compound fracture of the upper third of the humerus. The patient experienced immediate weakness and numbness of the arm. After a change of cast and manipulation of the fracture on March 23, 1945 (eleven days after injury), he noted the onset of severe constant burning pain in the palm of the hand. He was admitted to this hospital, April 23, 1945, incapacitated by this persistent pain. On hot sunny days the pain was particularly severe, while on cool rainy days there was slight relief. Cold, wet compresses on the hand produced a similar lessening of the pain. He carefully protected the left forearm and hand from contact with other objects. The left hand was pinker, warmer, and drier than the uninvolved hand. The nerve lesion could not be properly evaluated because of the marked aggravation of the pain produced by touching or moving the hand. A diagnosis of moderately severe causalgia of the left arm was made.

A paravertebral injection was done on April 23, 1945 (six weeks after injury), according to the technique described by White and Smithwick.¹ Fifteen cubic centimeters of 2 per cent procaine were injected along the left side of the bodies of the first and second thoracic vertebrae, producing marked vasodilatation of the hand and a typical Horner's syndrome within five minutes. The pain was completely relieved for one hour and then returned essentially unchanged as the procaine effect disappeared. An accurate examination of the peripheral nerves during the period of freedom from the pain revealed a slight median nerve paresis involving both the motor and sensory components. Function of the hand was poor due to periarticular thickening which produced considerable limitation of motion of all the finger joints. Four days later the paravertebral injection was repeated with similar prompt sympathetic paralysis and pain relief. Before the needles were withdrawn, 2½ c c of rectocaine were injected into each. The sympathetic paralysis and relief of pain persisted for forty eight hours, with the latter then returning with slightly lessened severity. Since it was felt that the amount of rectocaine was insufficient, a third injection was done on May 3, 1945 (nine days after the first injection and seven weeks after injury). After 5 c c of procaine injected at each segment had again produced prompt sympathetic paralysis and relief of pain, 4 c c of rectocaine were introduced into each of the two needles. This time the pain did not return and the relief persisted throughout the follow up period of ten weeks.

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*Containing 5 per cent benzyl alcohol propylaminobenzoate and procaine. From the C F Kirk Pharmaceutical and Biological Laboratories, New York, N Y

During the third week after this last injection the miosis of the Horner's syndrome gradually disappeared although the narrowing of the palpebral fissure remained marked. After four weeks the skin of the left arm and left side of the face became slightly moist but visible perspiration was still absent. During the seventh week the narrowing of the left palpebral fissure disappeared. Nine weeks after the last injection a partial sudomotor paralysis was still present. Exposure to the tropical sun for a few minutes at this time produced profuse perspiration over the right side of the face, right arm, and upper chest, and in contrast caused only a moist texture of the skin of the corresponding areas of the injected side. The large drops of perspiration covering the right side of the face and the right upper chest wall stopped sharply at the midline. When the patient returned to duty at the end of the tenth week he perspired nearly as copiously on the left side as on the right. Hand function had improved until there was nearly normal mobility of the finger joints. There was still a slight paresis of the median nerve which contributed to his relatively insignificant residual disability.

The sympathetic paralysis of the left side of the face was complete for two weeks, partial during the next seven weeks, and gradually disappeared during the tenth week. The sudomotor paralysis of the arm was essentially complete for four weeks and was then partially present until it also disappeared during the tenth week.

CASE 2—A 31 year old Chinese soldier sustained a penetrating gunshot wound of the right arm, March 16, 1945, which resulted in a compound fracture of the middle third of the humerus and a paresis of the median and ulnar nerves. Three days later a hot, throbbing, severe, constant pain appeared throughout the palmar surface of the right hand. This pain persisted unchanged until the patient's admission to this hospital on May 20, 1945. Examination revealed nonunion of the humerus with only slight pain at the fracture site. Moving the arm at this point did not alter the pain in his hand. The patient held the fingers of the right hand in extension and constantly protected the part against movement or contact with other objects. Even light touch on the palm caused marked aggravation of the pain. The pain was worse on hot sunny days and was somewhat relieved by cold wet compresses on the hand. The right hand was pinker and warmer than the left and the skin had a velvety texture to the touch. The vasodilatation was so extreme that moderate pressure with a pin in testing sensation frequently produced tiny drops of blood. The skin was equally moist in the two hands. Since he would permit only a sketchy examination of the hand the detailed delineation of the nerve lesions was postponed. Thus, the picture of a typical moderately severe causalgia was presented.

A paravertebral injection was done on May 25, 1945 (five and one half weeks after the injury). Two needles were inserted into the back down to the right side of the bodies of the first and second thoracic vertebrae in the manner described by White and Smithwick.¹ The needles were directed slightly more caudally than usual but otherwise the placement appeared to be satisfactory. Five cubic centimeters of 2 per cent procaine were injected into each needle, producing good vasodilatation of the hand and complete relief of pain within five minutes. A few minutes later a typical Horner's syndrome appeared. One ampule (5 cc) of rectocaine was then injected into each of the needles. The patient was kept in the left lateral decubitus position for one hour in an effort to prevent too wide spread diffusion of the drug. With the relief of pain an accurate examination of the functions of the peripheral nerves was now possible and severe but partial lesions of both the median and ulnar nerves were found to be present.

The complete relief of pain persisted throughout the follow up period of four months. The miosis and narrowing of the palpebral fissure almost completely disappeared after twenty four hours, while the anhidrosis of the right half of the face persisted for seven days. The right hand remained dry and warmer than the left with visibly dilated veins for two weeks, at which time the hand became moist and the same temperature as the left one. There was still no visible perspiration, however, although it was profuse on the normal side. Three weeks after the injection the patient perspired equally on the two sides.

In this case the sympathetic denervation of the right side of the face was much more transitory than that of the arm, presumably due to the placement of the needles more caudal to the stellate ganglion than usual. There was a complete sudomotor paralysis of the arm for two weeks with gradual recovery of this function during the third week. Subsequently the median and ulnar nerves were explored and the patient prepared for a bone graft of the humerus.

DISCUSSION

Paravertebral injection of procaine is being used extensively for the treatment of major and minor causalgia with satisfactory results in many cases, particularly the milder variety. In a series of 100 Chinese patients with causalgia (to be reported later) approximately 10 per cent were completely relieved of all pain either immediately or within four weeks after one, two, or three such injections. In an additional 40 per cent, adequate but not complete relief of pain resulted from repeated paravertebral injections of procaine. In the remaining 50 per cent the relief of pain was inadequate and a surgical attack on the sympathetic nervous system was usually necessary. The prolonged action of rectocaine promises to increase the effectiveness of temporary chemical sympathetic denervation of an extremity and to render a surgical sympathectomy less often necessary in the treatment of causalgia. The rapidity with which crippling trophic changes occur in the presence of persistent causalgia makes the prompt alleviation of the pain particularly important. Since patients not yet ready for a major surgical procedure tolerate paravertebral injections well, anything which will increase their effectiveness in relieving the pain will bear investigating.

This procedure should be of value in other conditions for which sympathetic denervation is indicated, that is, the vasospasm associated with injury or emboli of the great vessels, selected cases of peripheral vascular disease, angina pectoris and painful aortic aneurysms, severe hyperhydrosis, and selected cases of congenital megacolon.

The injection of alcohol to produce prolonged sympathetic paralysis, introduced by Swetlow,² has gained favor for certain conditions, but has several disadvantages which are avoided by the use of a nondestructive drug. The severe persistent pleuritic pain and intercostal neuritis occasionally produced by injection of alcohol in the thoracic segments should not occur and did not occur in either of the patients described. The sclerosing effect of the alcohol makes accurate placement of the needles of greater importance than when a nonsclerosing agent is used. After a primary failure, due to the scarring produced, secondary injections of alcohol are seldom successful. Although we have had no opportunity to investigate the point, repeated injection of rectocaine should theoretically continue to be effective.

The principal objection that might be raised to the use of a slowly absorbed agent like this is the fact that some adhesions may be produced around the ramus communicans and sympathetic chain which might make subsequent surgical dissection more difficult. This objection is, of course, present to a still

greater degree with the injection of alcohol. If a major operation can be avoided, the temporary Horner's syndrome is of little importance.

The usual safeguards against intravascular, intrathecal, and intrapleural injection must be rigidly observed. Preoperative medication with a barbiturate lessens the possibility of toxic reactions to the procaine. Injections for sympathetic denervation of the arm should be preceded by hypodermic administration of atropine in order to safeguard against syncope and other vagal reactions. The preliminary injection of 5 c.c. of procaine into each needle is necessary to verify promptly the proper placement of the needles and to prove that sympathetic denervation produces the desired relief of symptoms before the longer acting drug is injected. Also, in cases of an adverse reaction to the procedure, only a short acting drug need be counteracted. If a satisfactory sympathetic paralysis develops within ten minutes after injection of the procaine, one ampule (5 c.c.) of tetracaine should be injected into each needle.

The frequency with which major and minor causalgia is encountered in war wounds of the extremities prompted us to report the results in these first two cases although full evaluation of the procedure, its advantages, its disadvantages, and its possible complications must await further trial.

CONCLUSIONS

1. Paravertebral injection of a slowly absorbed anesthetic agent produced prompt and complete relief of pain in two patients with causalgia of the arm.

2. A persistent sympathetic paralysis was produced in each instance, gradually disappearing in ten weeks in Case 1 and in three weeks in Case 2.

3. Further trial of this procedure in causalgia and other conditions in which temporary sympathetic denervation is indicated seems to be warranted.

REFERENCES

1. White, J. C., and Smithwick, R. H. *The Autonomic Nervous System*, New York, 1941, The Macmillan Company.
2. Swetlow, G. I. Paravertebral Alcohol Block in Cardiac Pain, *Am. Heart J.* 1: 393-412, 1926.

TENON AND MORTISE GRAFTS FOR BRIDGING METACARPAL DEFECTS DUE TO GUNSHOT WOUNDS

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IN HOSPITALS in the Zone of the Interior, metacarpal fractures sustained in combat by high velocity bullets or shell fragments with loss of substance of a part or all of the metacarpal shaft are frequently seen. Many of these are complicated by extensive wounds of the soft parts, loss of tendon substance, and severance of the digital nerves. Obviously, when considerable damage to the soft tissues, tendons, and nerves exists, extensive surgical procedures to reconstruct these bone defects are not indicated. However, there are a number of cases in which damage to soft tissue is minimal, but the digit is useless because of loss of continuity of the metacarpal shaft, with resultant shortening of the metacarpal, this causes displacement of the joint into the palm, allowing the soft tissues to form a mechanical block. The adjacent interosseus muscles lose ability to flex the proximal joint. The head angulates into the palm causing hyperextension of the metacarpophalangeal joint. The patient objects to the appearance of the depressed knuckle and is justifiably disturbed at the prospect of sacrificing an apparently restorable digit. If other soft tissues and tendons are irreparably damaged, amputation, of course, is the simplest and most expeditious means of treatment. However, as Slocum and Pratt¹ and Bunnell² have pointed out, excision of a complete metacarpal, particularly the third and fourth, weakens the grasp considerably because of disruption of the metacarpal arch, frequently the adjacent digits angulate and rotate toward each other with resulting overlapping of the phalanges as the hand is flexed. This often constitutes a major disability.

OPERATIVE PROCEDURE

Faced with the problem of reconstructing a number of restorable digits, we have utilized an operative technique for which we claim no originality but which has been sufficiently successful to warrant its description. Adherent scars on the dorsum of the hand in the region of the operative site (invariably present in these penetrating wounds) should be excised at a preliminary stage. Usually, simple excision of scar with a small amount of undercutting of the skin and suture will be sufficient to provide an adequate covering. The involved metacarpal is approached through a dorsal incision either lateral or medial to the extensor tendon. The extensor tendon is retracted and the metacarpal shaft fragments are completely freed subperiosteally. The distal and proximal fragments are then resected until a transverse cortical surface can be obtained and the medullary canal reamed out with a drill and small curette for a distance of approximately 15 cm. The resulting metacarpal usually consists of only the head and base, occasionally with a very small

fragment of attached shaft. Traction on the involved digit at this time will demonstrate that the normal length of the metacarpal in most cases will be almost completely restored if too long an interval has not existed since the occurrence of the fracture. A cortical tibial bone graft the width of the normal metacarpal shaft, sufficiently long to bridge the gap completely in the involved shaft and, in addition, to allow a tenon to project approximately 1.5 cm. on the distal and proximal ends, is removed from the medial proximal

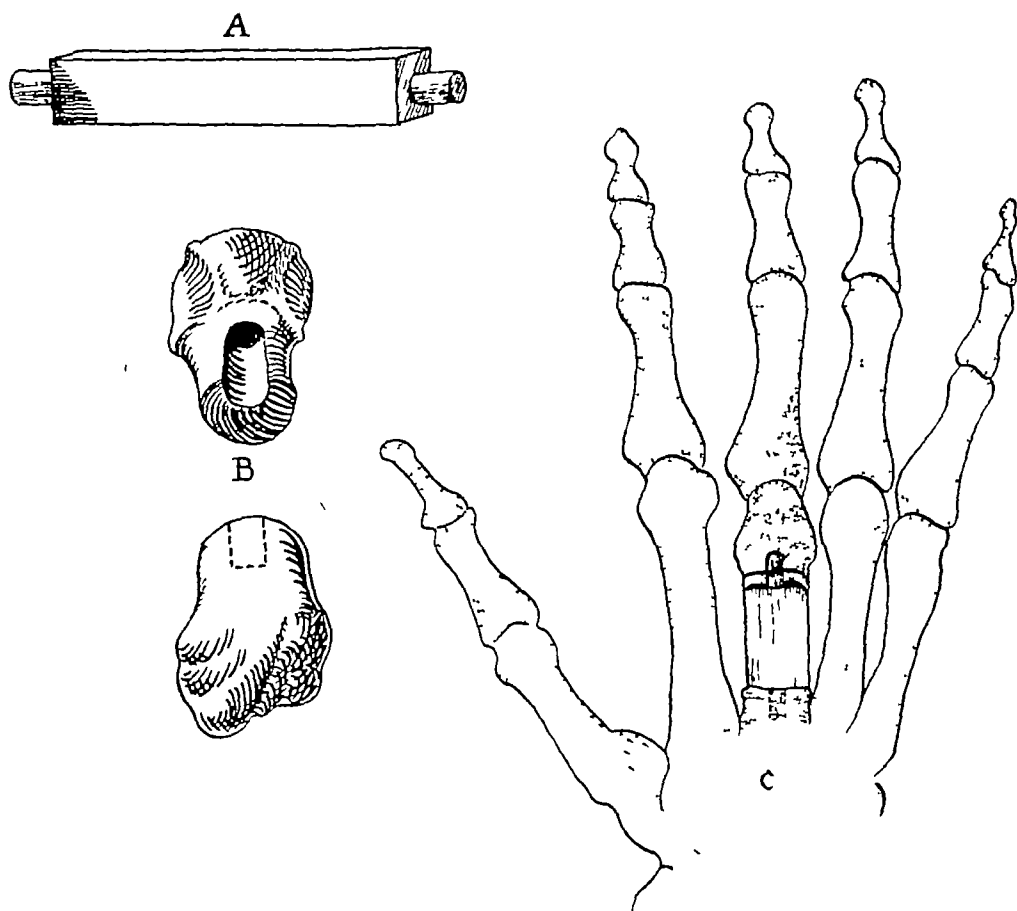


Fig 1—Schematic representation of operative technique. A, Graft with tenon cut and shaped (obtained from cortex of the tibia). B, Distal and proximal metacarpal fragments prepared for reception of graft. C, Graft in place, bridging metacarpal defect.

surface of the tibia with a motor saw. The endosteal portion of the graft is removed, leaving only the firm cortex. A shoulder is then cut about both the distal and proximal ends of the graft and the projecting tenon is rounded off. The burr of the Luck motor saw is extremely useful in accomplishing this task. Holding the graft during this procedure is somewhat difficult and Watson-Jones⁶ has suggested the use of a small mechanic's vice which can be sterilized and attached to the instrument table, this has been found to be exceedingly

work with and provides more secure internal fixation. The fact that all the fractures have united is evidence that while cancellous bone may provide more osteogenic tissue, this cortical bone provides adequate and probably excess osteogenesis." Bunnell² used a small key graft for nonunion, which is secured from the dorsal subcutaneous surface of the ulna and fits in the slot prepared in the metacarpal shaft. It is questionable, however, whether this procedure could be used to bridge a large defect. Bunnell stresses the importance of accurate fit and exact carpentry in repairing these small bone defects. Albee¹ devised a method in which a cortical tibial graft was inlayed in a fish mouth in the distal metacarpal fragment and an L-shaped tongue was inlayed in the proximal metacarpal fragment. The graft was held in place by sutures of kangaroo tendon through drill holes in the metacarpal cortex, which was successfully used in bridging the metacarpal shaft defect resulting from resection for extensive osteomyelitis.

Watson-Jones⁶ believed that "Although intramedullary peg grafting has no general application and in the case of most bones is far less satisfactory than onlay or inlay grafting, this technique is useful for internal fixation of recent fractures of small tubular bones, that is, the metacarpals, metatarsals, and phalanges."

The tenon and mortise type of graft already described is preferable to the simple intramedullary peg because structurally the graft is considerably stronger and the shoulders on each end of the graft buttress the cortex of the distal and proximal fragments of the metacarpal and prevent crushing of the cancellous bone, particularly of the distal fragment. The well-known cabinet-maker principle involved makes fixation extremely secure with the use of a minimum of foreign material. A graft of this type can be used to bridge a relatively large defect and restore and maintain the normal metacarpal length which is essential in securing a satisfactory cosmetic and functional result.

SUMMARY

1 The problems of gunshot wounds of the metacarpal bones with shaft defects have been described briefly and the indications for grafting reviewed.

2 A technique of tenon and mortise grafts for bridging metacarpal defects due to gunshot wounds, which has proved satisfactory in six cases, has been described.

3 This type of graft in indicated cases is considerably stronger than the intramedullary peg and provides a satisfactory cosmetic and functional result.

REFERENCES

- 1 Albee, F. H. *Bone Graft Surgery*, Philadelphia & London, 1915, W. B. Saunders Company.
- 2 Bunnell, S. *Surgery of the Hand*, Philadelphia, 1944, J. B. Lippincott Company.
- 3 Howard, L. D., Jr. *The Problem of Metacarpal Fractures of the Hand Due to War Wounds*, Lectures on Reconstruction Surgery of the Extremities, Ann Arbor, 1944, Edwards Brothers, Inc., p. 196.
- 4 Murray, G. *Small Bone Grafts of Extremities*, *Canad. M. A. J.* 48: 137-139, 1943.
- 5 Slocum, D. B., and Pratt, D. R. *The Principles of Amputations of the Fingers and Hand*, *J. Bone & Joint Surg.* 36: 535-546, 1944.
- 6 Watson-Jones, R. *Fractures and Joint Injuries*, ed. 3, Baltimore, 1943, Williams & Wilkins Company.

TWO UNUSUAL CASES OF WAR WOUNDS OF THE HEART

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TWO rare cases of cardiac wounds are presented which were of more than usual interest. In both, the operative procedures were successful.

PERFORATING (THROUGH-AND-THROUGH) SHELL FRAGMENT WOUND OF THE LEFT VENTRICLE

CASE 1—A 22 year old American private was wounded by an artillery shell fragment at 11 45 AM, June 27, 1944, near Vincenzo, Italy. He arrived at the Eleventh Field Hospital two hours later, in shock but conscious. There was no dyspnea nor hemoptysis. Nausea with vomiting occurred twice, shortly after admission. Examination showed a 3 cm lacerated wound in the fifth left intercostal space just outside the midclavicular line. The blood pressure was 80/60. The pulse was 110 and moderately weak but regular. The heart tones were normal and no adventitious sounds were heard. There were signs of fluid in the left pleural cavity. The abdomen was tender and resistant to pressure. A Levine tube was passed into the stomach and 250 cc of air and fluid were withdrawn. This material contained no blood. Intravenous plasma was started immediately, followed by blood transfusion. In two and one half hours, 1,000 cc of blood were given. The blood pressure had then risen to 130/70 and the pulse was 90. The abdominal signs and symptoms persisted. Roentgenograms were taken (Fig 1) and in the lateral projection the shell fragment was lying well posterior, apparently just within the rib cage. From the location of the wound, the apparent course of the missile, and the persisting belly signs, especially nausea and vomiting, a thoracoabdominal wound could not be ruled out. Accordingly, operation was commenced six hours after wounding and three one half hours after admission to the hospital.

Endotracheal anesthesia consisting of ether vapor and oxygen with carbon dioxide absorption was administered. A blood transfusion of 500 cc was given slowly during operation. After débridement, instruments and gloves were changed and an anterior thoracotomy performed in the fifth intercostal space by extending the wound of entrance. There was a chip fracture of the fifth rib. A small contusion of the lingula of the left upper lobe was noted but the diaphragm was intact. Five hundred cubic centimeters of blood were evacuated from the pleural cavity. The shell fragment was then discovered posteriorly, lying free. Two holes were seen in the pericardium: anterolaterally the pericardiophrenic artery and phrenic nerve had been severed (Fig 2), the posterior laceration was just lateral to the reflection of the parietal pleura from the pericardium on to the mediastinum. Five cubic centimeters of 5 per cent procaine were instilled into the pericardial sac, which was then opened by vertical incision after several minutes. There were two 8 mm lacerated wounds of the left ventricle, both oozing blood with each systole. The wound of entrance was at the apex, that of exit was in the mid portion of the left ventricular wall posteriorly (Fig 3). The apex of the heart was rotated 90 degrees forward and steadied by the right hand of the assistant. The posterior wound was exposed between the spread second and third fingers and the bleeding controlled by two No 0 silk sutures (Fig 4). A small venous branch was occluded by the sutures. The anterior laceration was irregular and the muscle gaped slightly. Oozing continued, particularly after one suture had cut partially through the muscle. The bleeding was controlled by fashioning a small pedicled graft of anterior pericardium and pericardial fat which was then sutured over the laceration (Fig 5). Extra systoles were numerous while the heart was being handled but they ceased immediately. Five grams of crystalline sulfanilamide and 50,000 units of penicillin were placed in the pleural cavity. Two water trap drainage tubes were used: a small mushroom catheter in the second intercostal space anteriorly, and a one-quarter inch fenestrated tube in the eighth intercostal space in the midaxillary line. The latter tube was clamped off for eight hours.

following surgery to allow for time contact of the chemotherapeutic agents. The incision was closed in layers using interrupted silk. Pericostal sutures were not employed. The operation was slightly more than two hours in length. At its conclusion the blood pressure was 110/70, the pulse, 145, and respiration, 32.

Following operation, nasal oxygen was administered for twenty four hours. The anterior catheter was removed in seventy two hours and the posterior tube on the fifth postoperative day. There had been 2,000 c.c. of serosanguineous drainage during this time. The blood pressure remained normal and the pulse stabilized at 100 to 110. Cardiac irregularities were never demonstrated. Twenty four hours after operation a splash was heard over the precordium, synchronous with systole. Four days later a loud precordial friction rub was audible for twenty four hours. At this time also the second sound in the pulmonary area was occasionally reduplicated. On the sixth postoperative day there was slight roughening of the first sound at the apex and a poorly transmitted soft systolic murmur was heard in this area.

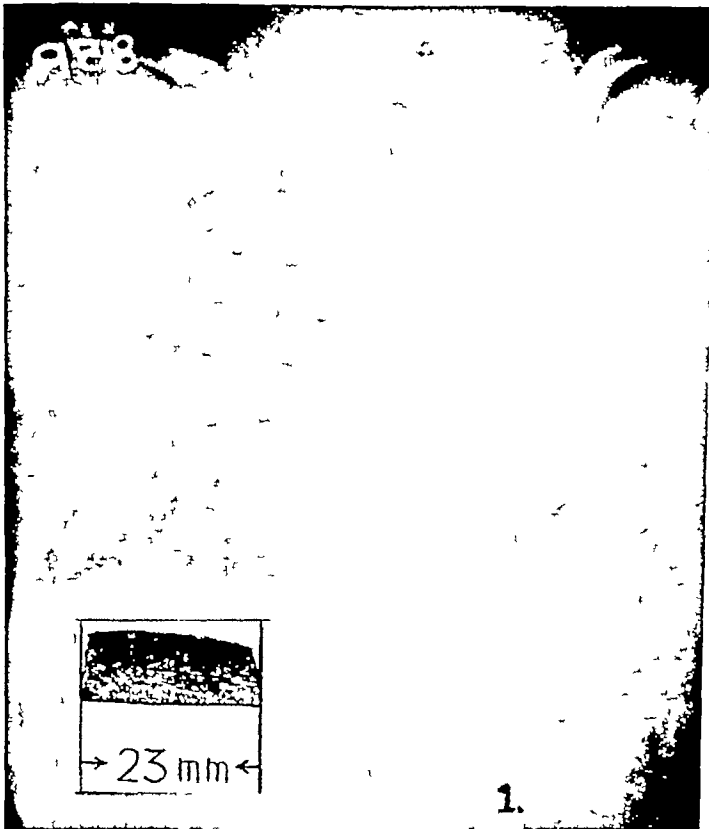
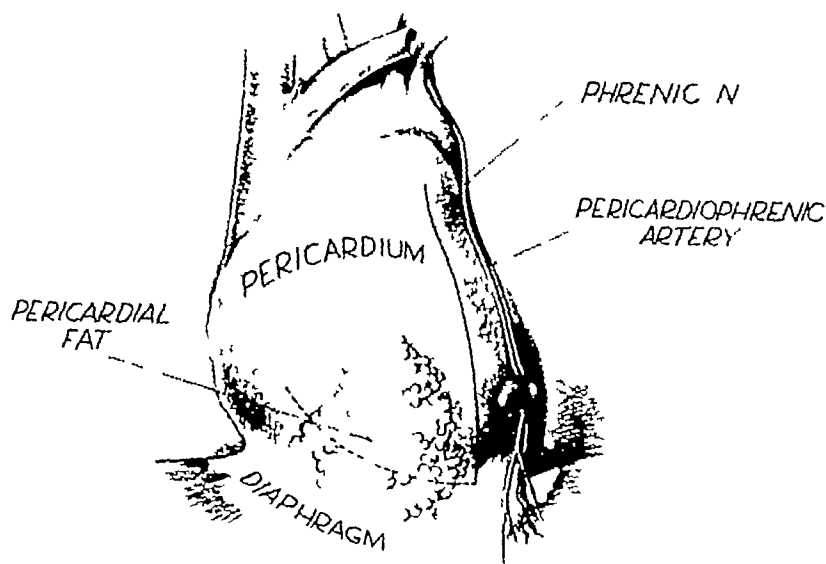


Fig 1.—Frontal view. There is a large hemothorax on the left which obscures the lung. The shell fragment (insert) measures 23 by 10 by 4 mm and lies at the ninth rib posteriorly. The Levine tube is seen faintly at the level of the eleventh intercostal space on the left.

An electrocardiogram was made at the Sixth General Hospital twelve days after operation. The rhythm was normal and the rate, 80. Moderate inversion of T waves, with elevated ST intervals in the first three leads, was reported. The T wave was normal in Lead IV. There was moderate left axis deviation. The patient became ambulatory three weeks after operation. A scratchy to and fro precordial friction rub was heard intermittently for an additional two weeks. Further observations were made at the 300th Gen



ANTERIOR ASPECT • N & VESSEL SEVERED

— INCISION FOR EXPOSURE
---- INCISION FOR FLAP

2

Fig 2—Drawing at operation showing the anterolateral laceration of the pericardium (wound of entrance) and the severed pericardiophrenic artery and phrenic nerve

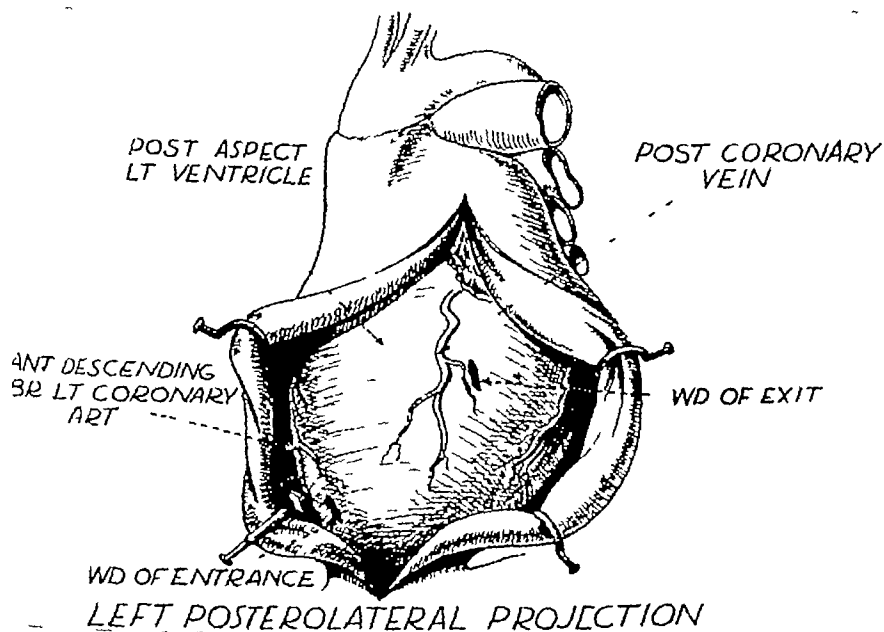


Fig 3—Semidiagrammatic drawing of heart as though viewed from left posterolateral aspect showing relationship of wounds to important vessels

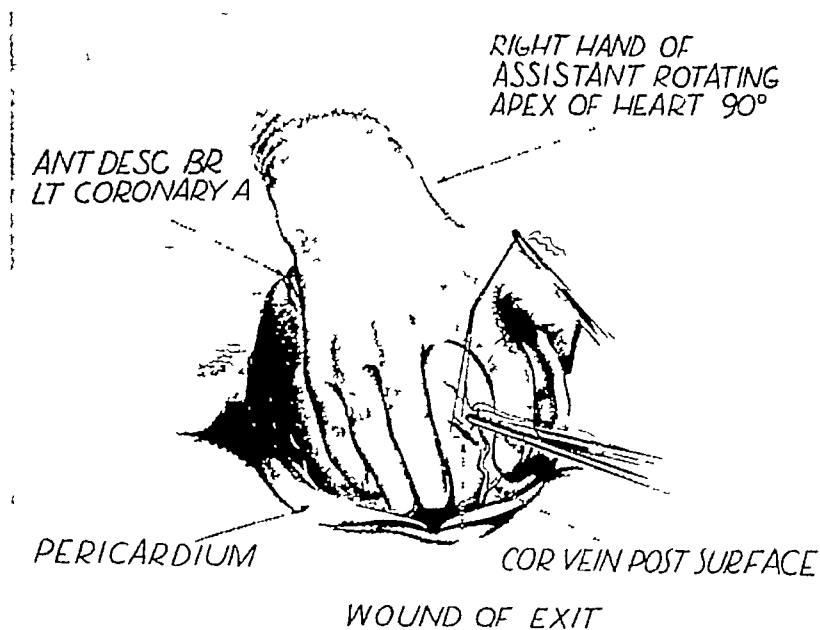


Fig 4—Drawing at operation showing method of steadying heart with exposure of posterior laceration

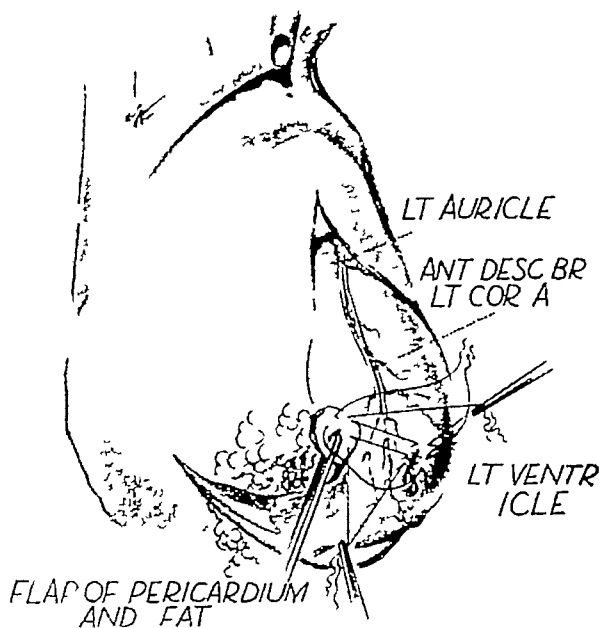


Fig 5—Drawing at operation the pedicled graft of pericardium is being sutured over the anterior lacerated wound

eral Hospital The lung fields were clear and the heart was not enlarged (Fig 6) Auscultation revealed neither friction rub nor murmurs An electrocardiogram showed mild myocardial damage, with improvement over the previous tracing No signs of cardiac embarrassment developed with increased activity The patient was evacuated to the United States eleven weeks after operation



Fig 6—Frontal view eight weeks following operation. The lung fields are clear the left diaphragm is elevated and paralyzed there is no cardiac enlargement. The chip fracture of the fifth rib anteriorly can be seen (arrow)

Comment—It has been of interest to us that severe perforating wounds of the heart are not necessarily fatal That this patient survived his original wound seems to have been due to a rare chain of circumstances The fragment must have struck end on and passed through the heart without revolving It seems probable, too, that the heart was pierced during diastole, which permitted traverse of the chamber without damaging irreparably the papillary muscle The case also demonstrates that there may be few if any localizing signs or symptoms in spite of a serious cardiac wound In retrospect one should consider that the patient's nausea and vomiting were probably cardiac in origin These symptoms are uncommon in pure thoracic injuries With the shell fragment free in the pleural cavity the apparent course of the missile was entirely misleading Had the missile struck from directly in front

it could not have failed to penetrate the diaphragm. The fragment, however, had come from the left, passed through the heart, and then fallen free in the pleural cavity, almost opposite the wound of entrance in an anteroposterior plane.

No published reports on perforating shell fragment wounds of the heart have been found. Boyden¹ recently has described a case similar to the one just reported, of perforating wounds of the left ventricle in which a branch of the posterior circumflex artery had been severed. Both wounds were sutured and the patient survived. Records of at least four other perforating cardiac

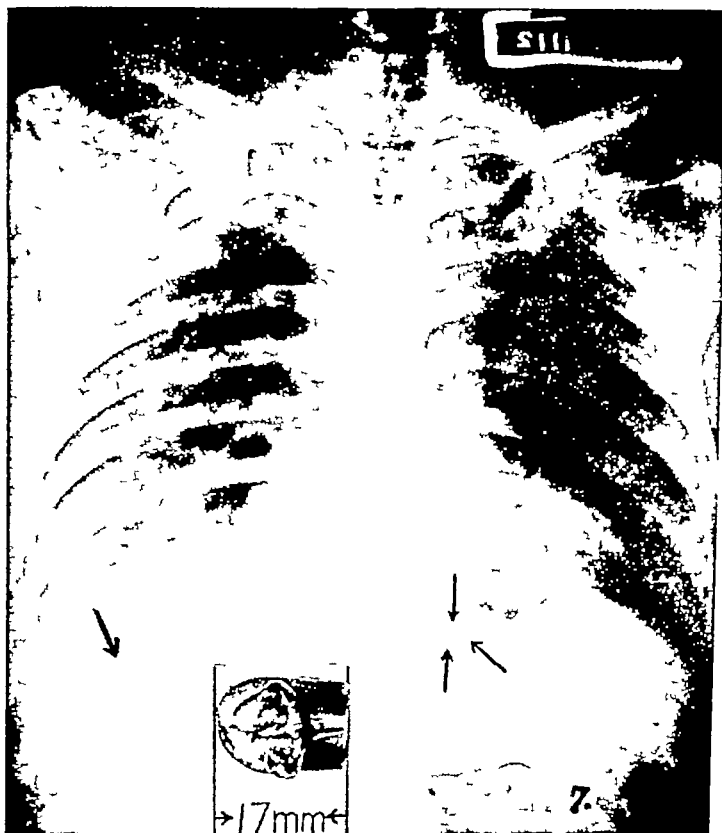


Fig 7—Frontal projection there is a fracture of the tenth rib posteriorly on the right (arrow) and a small right-sided hemothorax. The blurred foreign body (arrows) is seen lying 5 cm to the left of the midline. Insert shows the removed 45 caliber bullet, 17 by 10 mm. The nose is blunted and roughened apparently due to ricochet from a solid object.

wounds are now at hand in which the patient lived long enough to reach a forward hospital.² In one of these the interventricular septum had been traversed. It has not been possible to determine the incidence of perforating cardiac wounds in civil practice. Undoubtedly some of the cases listed by Elkin, Biggel, and others were perforating in type. Probably one of the earliest examples of operative success was that reported by Launay (1902)³ in which the wound was self-inflicted. The bullet was found to have passed through the left ventricle. Both wounds were repaired and the patient recovered.

INTRAVENTRICULAR METALLIC FOREIGN BODY

CASE 2—On Nov 21, 1944, a 38 year old German sergeant was wounded in the right chest posteriorly by a 45 caliber bullet as he was ascending from a dugout. The bullet apparently ricocheted before striking him. The prisoner was knocked down by the impact but did not lose consciousness. Except for hemoptysis and moderate dyspnea he suffered little discomfort. The patient was admitted to the Ninth Evacuation Hospital five days after wounding. Examination showed a 3 cm superficially infected, lacerated wound over the tenth right rib in the midscapular line. There were signs of fluid at the right base. The blood pressure was 120/78, and the pulse was 90 and regular. No cardiac pathology could be detected. Roentgenograms in frontal and lateral projections were made (Figs 7 and 8). At fluoroscopy the foreign body descended slightly on inspiration. It could be separated from the diaphragm but remained always within the cardiac shadow. During systole there was a 3 cm excursion of the missile from left to right, with return to the original position during diastole. The location and movement of the foreign body did not vary at two subsequent fluoroscopies. These studies demonstrated that the bullet was in the heart.

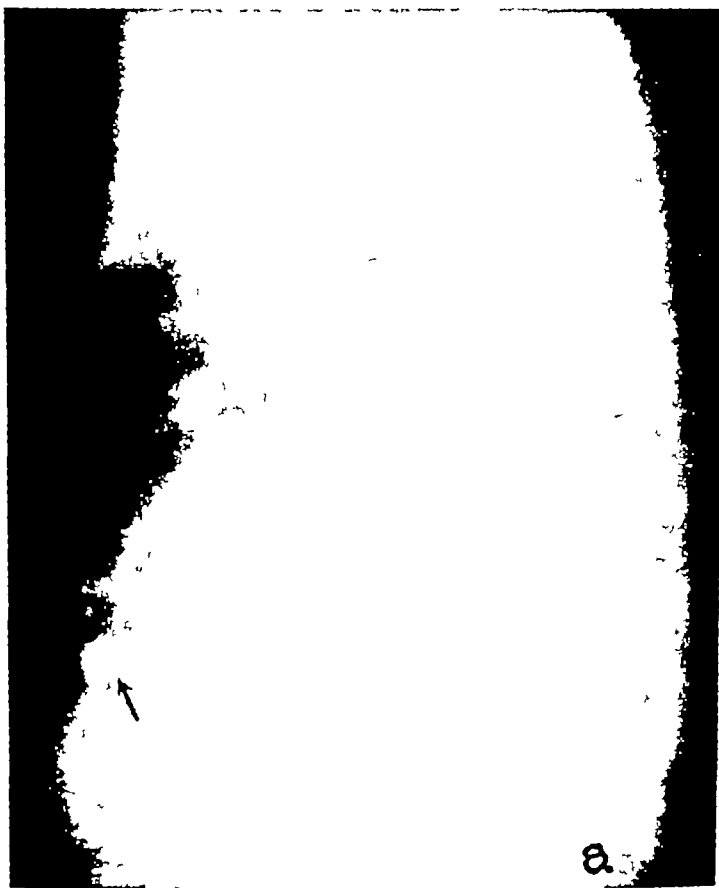


Fig 8—Left lateral projection the blurred foreign body (arrows) is seen lying 4.5 cm beneath the skin surface anteriorly

Operation was undertaken seven days after wounding. Closed endotracheal anesthesia of ether vapor and oxygen was given. An anterior left sided approach was used since the foreign body lay to the left of the midline. Incision was made from the sternum to the maxilla and the left pleural cavity was entered through the fifth intercostal space. The

internal mammary vessels were ligated and divided. The pericardial sac was opened by a vertical incision anterior to the phrenic nerve. It contained a few cubic centimeters of serous fluid. Ten cubic centimeters of 5 per cent procaine were instilled. No lacerations either of the pericardium or of the myocardium were demonstrated. During diastole the missile could be palpated through the wall of the right ventricle, 3 cm to the right of the apex. Its position was checked with a fine needle. The heart was steadied in the left hand by the "palming" method.⁴ A 1.2 cm incision, parallel to the inferior cardiac border, was made down to the foreign body. It was grasped with forceps and removed. There was an immediate gush of blood from the chamber of the right ventricle. This was controlled by thumb pressure while three No. 0 interrupted silk sutures were rapidly inserted and tied by the assistant. There was no further bleeding. Dilatation and ectopic beats developed during cardiac manipulation but there was spontaneous return to normal rhythm when the heart was released. The pericardium was closed above, and opened posterior to the phrenic nerve for more dependent drainage. Anterior and posterolateral drainage tubes were inserted and 25,000 cc of penicillin were injected into the pleural cavity. The incision was closed in layers using interrupted silk. The operation consumed one hour and fifty minutes. At its finish the blood pressure was 98/68, and the pulse 100 and regular. Five hundred cubic centimeters of whole blood were given slowly during operation.

The postoperative course was complicated only by a superficial infection in the thoracotomy incision. The lung expanded promptly and the drainage tubes were removed on the second and third days. Bilateral thoracentesis on the fourth day was productive of 150 cc of clear serum on the left and 250 cc of old blood on the right. The heart remained regular and no friction rub was heard at any time. The patient was transferred to the Twenty-first General Hospital for study. An electrocardiogram which was taken twelve days following operation showed myocardial damage. The QRS complex was buried in Lead III and the T waves were inverted in all leads, with coning of the ST segments. There was marked low voltage in Lead III. The patient was discharged to ambulatory convalescence in a prisoner of war hospital, ten weeks after operation.

Comment—In Case 2 the bullet obviously did not traverse the myocardium. In view of the bullet's size and known hitting power, residual damage to the pericardium and myocardium would have been evident seven days after wounding had the missile entered the heart directly. The foreign body undoubtedly entered the venous system just outside the pericardium and was washed into the right ventricle. Whether the superior or inferior vena cava was penetrated cannot be stated definitely. Unknown factors are the exact position of the soldier at the time of wounding and the angle at which the shot was fired. Since the tenth rib was fractured posteriorly the inferior vena cava easily could have been the portal of entry. That its force was spent is evidenced by the blunted nose of the bullet (see insert, Fig 7), indicating that it had glanced off some solid object before striking the soldier.

Indications for removing foreign bodies from the cardiac chambers have not been clarified. Cardiotomy is not without risk and many of the missiles may remain asymptomatic. On the other hand, delayed complications and fatalities have occurred due to the continued presence of a foreign body. The intracardiac missile may be the cause of fatal secondary pulmonary emboli.⁵ Lyle⁶ reported a case in which a shell fragment entered the left femoral vein and came to rest in the right heart. A generalized "gas" infection from this focus resulted in death. Jarvis⁷ has described a case in which a shell frag-

ment entered the vascular system through the inferior vena cava in the abdomen. The patient died suddenly ten days after injury and at autopsy the irregular foreign body 20 by 15 by 10 mm was found in the right ventricle. The myocardium of the right ventricle near the apex was extensively softened and hemorrhagic in the area overlying the missile.

Certain hazards also must be expected if the fragment enters the pulmonary circulation from the right heart. While I have no personal knowledge of such a case, it is theoretically possible for the missile itself to become an embolus which is immediately fatal. The removal of foreign bodies from the pulmonary vessels may be difficult and involve the loss of an essential artery. Lobectomy or even pneumonectomy might become necessary under certain conditions. In one of Burford's cases⁸ it was felt unwise to remove an asymptomatic missile which had become lodged in the right main pulmonary artery because of the likelihood that the artery would have to be sacrificed.

Harken⁹ has removed a number of foreign bodies successfully from various chambers of the heart. Unless localizing cardiac symptoms persist, the operation, in most instances, should not be considered an emergency. In general, it is preferable to transfer the patient to a special base section hospital where there may be better facilities for study and for continuity in postoperative care. Final conclusions as to indications for cardiectomy must await eventual critical comparison between the results from operation and those from conservative management.

SUMMARY

Two cases of unusual cardiac wounds have been presented and the surgical treatment described. The first patient suffered a perforating (through-and-through) shell fragment wound of the left ventricle. Both wounds were sutured and the soldier survived. In the second patient a 45 caliber bullet entered the venous system just outside the pericardium and came to rest in the right ventricle. The missile was removed by incision through the ventricular wall. The patient made an uneventful recovery.

The author is indebted to Technician Fourth Grade Walter Meigs Jr. who made the drawings which are reproduced in this paper.

REFERENCES

- 1 Boyden, Allen A. Personal communication, operation by W. P. Jennings and Boyden.
- 2 Case Records of the Second Auxiliary Surgical Group. Unpublished data.
- 3 Launay. *Gaz. d. hôp.* 75: 926, 1902, quoted by Lihenthal.*
- 4 Lihenthal, Howard. *Thoracic Surgery*, vol. I, Philadelphia, 1925, W. B. Saunders Company, page 448.
- 5 Tuffier, T. *V. Cong. de la Soc. internat. de chir.*, Paris, p. 46, Paris.
- 6 Lyle, H. H. M. *Ann. Surg.* 64: 734, 1916, quoted by Lihenthal.*
- 7 Jarvis, Fred J. Personal communication.
- 8 Burford, Thomas H. Personal communication.
- 9 Harken, Dwight. Personal communication. See also *J. Thoracic Surg.* 15: 31, 1946.

THE EFFECT OF ATROPINE ON THE GASTRIC SECRETION FOLLOWING THERMAL TRAUMA

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VOMITING, occult blood in the stools, and the development of peptic ulcers (Curling's ulcer) have been described following burns in the human being^{1,2} In the dog, a significant increase of gastric motility, particularly of the gastric antrum, has been found. Gastric secretion was increased in these animals when intravenous infusions had been administered. The secretions seemed to be higher when the animals had been fed the night before the experiment. The strong gastric motility following burns was not abolished by section of the vagus or of the splanchnic nerves. It was abolished, however, by the injection of relatively small doses of atropine. On the basis of this work, the use of atropine in the treatment of patients with burns was suggested, because it was felt that the intense motility of the stomach, and particularly of its pyloric part, might lead to ulcerations^{3,4} Since the effects of atropine on the gastric secretion following burns are not known, they were investigated in the present study.

EXPERIMENTAL PROCEDURE

Normal mongrel dogs, fed eight to nine hours before the experiment, were anesthetized with pentobarbital sodium (nembutal) and were kept under anesthesia during the entire experiment. Unless the animals died, they were destroyed painlessly at the termination of the experiment. The hair was clipped over the area to be traumatized. The esophagus was ligated in the neck and a cannula was inserted into the pylorus. The cannula was directed to the outside so that the gastric juice could be drained into a bottle, volume and acidity were determined periodically. Intravenous infusions were given at constant rates,⁵ most animals receiving 1 c.c. per minute per kilogram of body weight of either 0.9 per cent saline or 5 per cent glucose solution, or a mixture of both. Fifteen minutes before the burn, 5 or 10 mg. of atropine sulfate were injected intravenously and every half hour after the burn doses of 5 mg. were given (slow rate of injection). Thermal trauma was administered by torch to approximately 50 per cent of the body surface. The duration of the traumatization varied between ten and twenty minutes, but it is not believed that this expresses the degree of traumatization, because a number of other factors like thickness of the skin, of the subcutis and fat layers, of the musculature, etc., seem to affect penetration of heat. Autopsies were performed on all animals. Control experiments were performed on two anesthetized dogs. The procedures were the same as in the burn experiments, except that no trauma was applied.

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RESULTS

In the control experiments, the volume of secretion per hour (collected through a cannula) varied between 1 and 4 c.c. No free acidity and small or medium amounts of total acidity were found. Four similar control experiments, reported in our previous work,³ are included in the lower part of Table I. The volume of secretion in the earlier experiments was within the magnitude of the secretion observed in the present controls, and no free acidity was present. Thus, considerable changes in the secretion following burns were assumed not to be due to conditions of the experiments other than the burn.

TABLE I CONTROLS—GASTRIC SECRETION WITHOUT THERMAL TRAUMA

NUMBER OF DOGS	SECRETION IN C.C. PER HOUR				ACIDITY IN M.E. HCl (FREE—TOTAL)			
	1ST	2ND	3RD	AV	1ST	2ND	3RD	AV
1	1.5	1.0	4.0	1.2	0.55	0.40	0.20	0.38
1	4.0	2.5	1.0	2.5	0.10	0.5	0.5	0.7
4				2.9				0

In Table II is represented the summary of twenty-four experiments with thermal trauma. Twelve control experiments without drug administration were performed, and in twelve experiments atropine was given. In most instances the greater part of the secretion following the trauma occurred within the first thirty minutes after the burn, while a smaller fraction was secreted or evacuated during the remainder of the period of observation.

TABLE II GASTRIC SECRETION FOLLOWING THERMAL TRAUMA

PROCEDURE	NUMBER OF EXPERIMENTS	DURATION IN MIN.		VOLUME SECRETION IN C.C.		FREE ACID IN M.E. HCl		TOTAL ACID IN M.E. HCl	
		BEFORE BURN	AFTER BURN	BEFORE BURN	AFTER BURN	BEFORE BURN	AFTER BURN	BEFORE BURN	AFTER BURN
No atropine	12	80	100	10	26	0	7	23	48
		(60-120)	(60-155)	(0-1.35)	(0.5-60)		(0-40)	(1-75)	(10-150)
Atropine	12	94	97	10	26	4	13	31	46
sulfate		(60-120)	(60-120)	(1-31)	(3-120)	(0-35)	(0-70)	(5-100)	(20-140)

Average values minimal and maximal variations in brackets

DISCUSSION AND CONCLUSIONS

The data in Table II show that atropine had no effect on the volume and acidity of secretion following thermal trauma, although the doses of atropine (up to 30 mg.) were large in comparison to those which in our previous observations completely suppressed the gastric motility following burns (2 mg.). After the burn, the average free acidity did not rise much, while total acidity showed a somewhat larger increase, irrespective of whether atropine had been administered or not.

In our previous work we had assumed that the gastric hypermotility of burns was due to a cholinergic mechanism, because it was abolished readily by atropine.³ The present observation that relatively large doses of atropine do not depress the increased gastric secretion of fluid and acid following a torch

burn indicates that we may be dealing with a histamine-like substance liberated by the burn, the gastric secretory effects of which are not abolished by atropine. It appears thus, that the gastric secretion and the gastric motility of burns in dogs are activated by two different mechanisms.

Assuming that our experience in the dog can be applied to man, we have recommended atropine against the vomiting and other gastrointestinal symptoms following burns in the human being which, we believe, may lead to mucosal hemorrhage and to the development of acute ulcers which later may become subacute and bleed or perforate. Following our present experience with the ineffectiveness of atropine on the increased gastric secretion following burns we feel that we should recommend the use of antacids in addition to atropine. Such therapy would take care of both the increased motility and the increased secretion of burns. Atropine may have other more general effects in shock. The drug has been reported to prolong the life of rats subjected to traumatic shock,⁶ and we have gained the same impression in unpublished series of experiments.

SUMMARY

Relatively large doses of atropine did not affect the increased gastric secretion of the dog's stomach following burns. Since gastric hypermotility of burns is suppressed completely by atropine, it is assumed that, in burns, two different mechanisms activate gastric secretion and gastric motility. Gastric motility of burns may be due to a cholinergic mechanism, and gastric secretion of burns may be due to a histaminic mechanism.

If these findings can be applied to the human being, atropine and an antacid are recommended in cases of burns, in order to prevent vomiting, gastrointestinal hemorrhages, and the formation of ulcers.

REFERENCES

- 1 Cope, O., and Rhinelander, F. W. The Problem of Burn Shock Complicated by Pulmonary Damage, *Ann Surg* 117 715, 1943.
- 2 Harkins, H. N. Acute Ulcer of the Duodenum (Curling's Ulcer) as a Complication of Burns. Relation to Sepsis, *SURGERY* 3 608, 1938.
- 3 Necheles, H., and Olson, W. Experimental Investigation of Gastrointestinal Secretions and Motility Following Burns and Their Relation to Ulcer, *SURGERY* 11 751, 1942.
- 4 Necheles, H., and Olson, Wm. H. Studies on the Pathological Physiology of Burns, *Illinois M J* 84 6, 1943.
- 5 Necheles, H., and Olson, Wm. H. A Simple Constant Injection Pump, *J Lab & Clin Med* 26 1647, 1941.
- 6 Zahl, P. A., Hutner, S. H., and Cooper, F. S. Noble Collip Shock. Therapeutic Effects With Autonomic Depressants, Motion Factors, *J Pharmacol & Exper Therap* 77 143, 1943.

BILATERAL POPLITEAL HERNIA

CASE REPORT

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THIS case report is of special interest because of the rarity of bilateral popliteal herniation of the knee joint. It is believed that this represents only the second case reported. Haggart, who has published articles on this condition, mentions one other bilateral case.¹ The condition probably is not considered very frequently in diagnosis of popliteal swellings.

A popliteal hernia is generally defined as a synovial outpouching of a cystlike structure through the knee joint capsule, which causes symptoms suggesting an internal derangement of the knee. The term Baker's cyst is frequently used in the British publications to describe any cystic swelling about the posterior knee joint which is lined with synovium.¹ However, in these publications the cysts referred to are enlargements of the bursae in that area. In popliteal hernia the cyst is a protrusion of the synovial membrane of the joint through the joint capsule.

According to Haggart, the etiologic factors of herniation of the knee joint capsule are trauma, especially sudden trauma associated with forceful hyperextension of the knee joint, and perhaps some congenital defect.² It is commonly associated with hypertrophic arthritis in the knee joint.

Pathologically, this portion of the capsule is thickened, fibrotic, and typically lined with a mesothelial membrane similar to the synovial membrane of the knee joint itself. Acute and chronic inflammatory changes are noted in the sac wall with round-cell infiltration being most notable. Grossly, the sac is usually adherent to the medial head of the gastrocnemius muscle. The neck of the sac communicates with the knee joint and may be dissected free with care.

Clinically, the patient presents symptoms of discomfort and aches in the knee joint. The posterior portion of the knee joint swells and walking is a painful procedure. The lower leg and ankle swell intermittently, apparently from the pressure of the popliteal mass on the venous system.

Physical examination shows a cystic swelling posterior and distal to the transverse flexion crease of the knee. The mass feels like an elastic ball and is frequently reducible when the knee is flexed. Roentgenograms of the knee joint are noncontributory to the diagnosis.

In differential diagnosis it is important to recognize that the semimembranosus bursa which occasionally swells is more medial than the typical popliteal herniation, while the semitendinosus bursa is more lateral. It should also be kept in mind that aneurysms have a typical pulsation. Gelatinous fluid can be aspirated with a syringe from the hernial sac. If the cyst con

tents can be reduced into the joint with the knee flexed, the diagnosis is obviously hernia

The treatment of choice is operative excision of the hernia with ligation and closure of the neck of the sac. The capsule is then reconstructed with sutures.



Fig 1—Postoperative result.

CASE REPORT

An 80 year old man came to the Mandel Clinic of Michael Reese Hospital complaining of progressive pain and swelling of both knees, with discomfort and difficulty in walking, over a period of three months. No history of trauma was elicited. The patient had a generalized hypertrophic arthritis of the fingers, elbows, and knees. On admission he could walk only with short painful steps.

Past history revealed nothing related to the present disability.

Physical examination disclosed blood pressure to be 130/70, pulse 82, and respirations 20. The patient was not acutely ill, but obviously had difficulty in walking and used

a cane for support. His steps were measured and painful. Essential findings were scoliosis to the left side of the thoracic spine, and hypertrophic arthritis of the hands, knees, and ankles with some valgus deformity of the knees. The popliteal space bilaterally contained egg sized, firm, smooth, elastic and somewhat movable tumor masses, not attached to the skin. The mass on the left side was reducible with flexion. The presumptive diagnosis was bilateral popliteal hernia.

The operation consisted of a posteriorly placed longitudinal incision down to the deep fascia of the left knee (Fig 1). The fascia was incised and the cystic mass presented itself. The mass was dissected from the adjacent tissues by blunt and sharp dissection. The lateral and medial heads of the gastrocnemius muscle were retracted and at its superior portion the sac was firmly adherent by fibrous strands to the fascia of the medial head of the gastrocnemius muscle. Superiorly the cystic mass terminated in a neck which communicated with the joint of the left knee just lateral to the semimembranosus muscle. This was a herniation of the synovial membrane through the knee joint capsule. The sac contents could be completely reduced and its contents could be transferred back and forth into the knee joint. The sac was dissected free at its neck. The neck of the sac was closed with interrupted chromic catgut sutures which inverted the edges, and the capsule of the knee joint was also closed with fine interrupted chromic sutures. Hemostasis was good. Fascia was closed and the skin was closed with dermal sutures. Firm pressure dressings were placed on the incision. The right knee was operated upon in a similar manner. However, the lining of the neck of the sac of the right knee was obliterated by adhesions and constricted so that the sac contents were not reducible. The fluid in the sac was gelatinous with pearly particles much like villi floating about.

The postoperative course was uneventful. Because the patient was an old man, early motion was thought to be very important. Thus is a departure from the full extension splint which Haggart uses. On the first postoperative day the patient was placed in a wheel chair. Therapeutic light treatments were given to both knees daily. By the fourth postoperative day most of the pain was gone and the patient was quite comfortable. On the sixth postoperative day, sutures were removed. The wound healed very well. Edema was minimal. On the tenth day the patient was discharged. At subsequent follow up visits, the elderly patient has been found to be much happier, entirely relieved of the distressing knee pain, and now able to walk with ease.

SUMMARY

- 1 An unusual case of bilateral knee joint hernia into the popliteal space is reported.

- 2 The distressing symptoms of this condition can be relieved by surgical removal of the hernia sac and repair of the capsule defect.

REFERENCES

1. Haggart, G. E. Posterior Herniation of Knee Joint, A Cause of Internal Derangement of the Knee, *J Bone & Joint Surg* 20 263-273, 1938.
2. Haggart, G. E. Synovial Cysts of the Popliteal Space, Clinical Significance and Treatment, *Ann Surg* 118 438-445, 1943.

CLOSURE OF THE COLOSTOMY STOMA

A SIMPLIFIED PLAN OF MANAGEMENT

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CLOSURE of the colonic stoma, as seen in the wounded soldier, presents two main problems (1) What technique is applicable to the various types of colostomies seen? (2) Of what value is chemotherapy in conjunction with closure of these stomas?

We wish to present the plan of management of colostomy closure which we have followed in the past twenty-three colostomies. We would point out that the technique of closure should be chosen for each patient according to the type of colostomy present as revealed by digital examination. Chemotherapy has proved its worth in our hands in the prevention of infection and promotion of healing.

Concerning the technique of closure, Keene³ has recently advocated and reported excellent results in resecting the bowel involving the stoma, and restoring continuity of the colon by end-to-end suture. Collier and Vaughan¹ stated that they had resorted to end-to-end union for colostomy closure with gratifying results. Both Collier and Vaughan¹ and Pemberton and Black⁴ have advocated the use of delayed closure of the abdominal wound.

The first large series of colostomy closures in which the effect of chemotherapy was seriously evaluated was reported by Dixon and Benson² in 1944. By the preoperative use of succinylsulfathiazole in the field of operation they were able to reduce wound infection from 84 to 13 per cent, fecal drainage from 30 to 2 per cent, mortality from 3 to 0 per cent.

Stimulated by our observation of the beneficial effects of chemotherapy in secondary wound suture, we have adopted both penicillin and sulfonamide therapy for colostomy closure.

PREOPERATIVE AND POSTOPERATIVE MANAGEMENT

Each patient was placed on a definite preoperative routine, as soon as the colostomy was adjudged suitable for closure. Our criteria for establishing readiness for suture were (1) that the nutrition of the patient be definitely improving, (2) that edema had receded from the stoma, (3) *that digital examination reveal an adequate lumen obtainable when the bowel was sutured*. Seventy-two hours were routinely used for preparation. The patient was placed on a low residue, high carbohydrate diet. The proximal and distal loops of the colostomy were irrigated daily, the last irrigation being carried out twenty-four hours before operation. On the first day of preparation 4 Gm of sulfaguanidine were administered every four hours for six doses, followed by 2 Gm doses of the same drug every four hours up until four hours before closure. Tincture of camphorated opium was given in 2 dr doses every four hours for twenty-

four hours before operation. The bowel was aspirated the evening and morning before the patient was operated upon. Postoperatively, the patient's oral intake of fluid was restricted until flatus was passed, which usually occurred within twenty-four hours after suture. Water balance was maintained by intravenous fluids, gastric suction was used, when indicated. Penicillin and sulfadiazine were both used for seven days after operation. Penicillin was administered by the intramuscular route in doses of 20,000 units every four hours. Five grams of sulfadiazine were given daily. The first twenty-four hours sodium sulfadiazine was given intramuscularly. Thereafter, 1 Gm was ingested every four hours by the oral route.

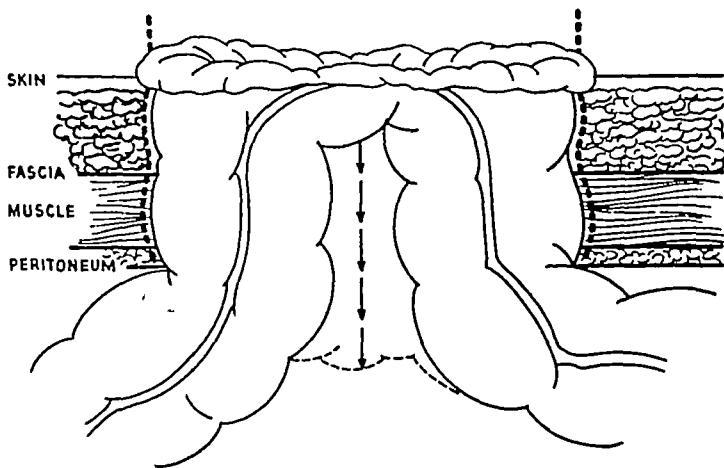


Fig 1.—Digital examination reveals that no spur is present. Bowel can be invaginated into abdomen securing adequate lumen, as illustrated in Fig 2. Dotted line represents the incision carried through posterior fascia not through peritoneum. After closure of the opening in the colon peritoneum may be opened to eliminate angulation.

SURGICAL TREATMENT

Colostomies, as we have observed in wounded soldiers, have been established either for diversion of the fecal stream to allow healing of the bowel at a point caudad to the stoma or as a result of exteriorization of the damaged bowel. We have found that, regardless of the purpose for which a colostomy had been established, the findings on *digital examination* can determine the technique of closure best suited for restoration of continuity of the colon for that particular patient. Our cases, based upon information gained from digital examination, fall into four categories. In Fig 1 is shown the type of colostomy most easily closed. We shall describe our technique in some detail for this type, and then show how it is modified for the other types encountered. In this type of stoma no spur has formed, and when it is examined, gentle pressure with the index finger invaginates the posterior wall of the bowel into the peritoneal cavity, an adequate lumen is readily assured, as demonstrated in Fig 2. An elliptical incision is made encircling the protruding bowel, and carried down to, but not into, the peritoneal cavity. The colon is thus readily freed from the abdominal wall. The skin is excised from the edges of the bowel, and any rolled-over edge

of bowel, adherent to skin, is carefully dissected free and preserved. The edge of the mucosa is not freshened. Only redundant mucosa is excised. Continuous chromic catgut No. 00 on an atraumatic needle is used for the first row of sutures. These stitches are placed just in the edge of the serosa, so as to invaginate as little bowel as possible consistent with watertight closure. When this row has been placed, sulfanilamide crystals are sprinkled over the suture line, drapes are changed, and gloves washed. A second row of Halsted sutures of fine cotton is placed in the seromuscular layer turning in as little bowel as is consistent with snug closure. After the suture line is complete, the peritoneum is opened sufficiently to allow the colon to be placed beneath the fascia without angulation or tension. The abdominal wound is closed in layers by means of interrupted sutures of fine cotton. Sulfanilamide crystals are sprinkled in the wound during closure, a total of 5 Gm. being used in the wound and over the point of suture of the bowel. A drain is used rarely and then only in those patients in whom extensive oozing occurs. In such an instance it is placed only subcutaneously, and allowed to remain only forty-eight hours to evacuate accumulated hematoma.

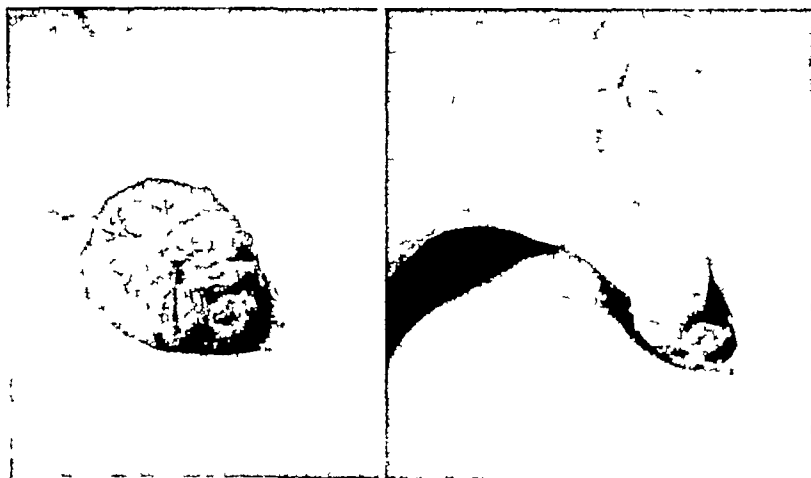


Fig. 2—Photograph of type colostomy diagrammed in Fig. 1. Note that gentle pressure against the posterior wall of the stoma reveals no spur; adequate lumen. Edema has disappeared from the stoma.

If a long, thin spur is present, as illustrated in Fig. 3, crushing clamps are applied in the traditional manner to the spur. When sufficient channel has been produced, and the edema has regressed from the bowel, the colostomy is closed. Usually in this type of case it is found advantageous to open partially the peritoneum before suturing the bowel. This enables the operator to mobilize the limbs of the colostomy, and so obviate tension on the suture line. By leaving the more medial portion of the colon attached to the parietal peritoneum, the closed stoma can be placed in a compartment in the lateral gutter (in the case of a colostomy in either the right or left colon), fairly well sealed off from the general peritoneal cavity. This area of attachment, if properly placed, does not produce tension or angulation at the suture line.

In Fig 4 is illustrated a condition in which a thick spur is present, but interposed between the two limbs of the spur is a palpable mass. The application of a crushing clamp to such a spur carries with it the risk of grasping a loop of adherent small intestine, thereby producing a troublesome fistula, if not a fatal peritonitis, or the risk of crushing a large mesenteric artery, producing gangrene of a segment of colon. In such cases we have deemed it wise to open the peritoneal cavity liberally, to mobilize the limbs of the colostomy, to free the points of adherence between proximal and distal loops, and then to suture the

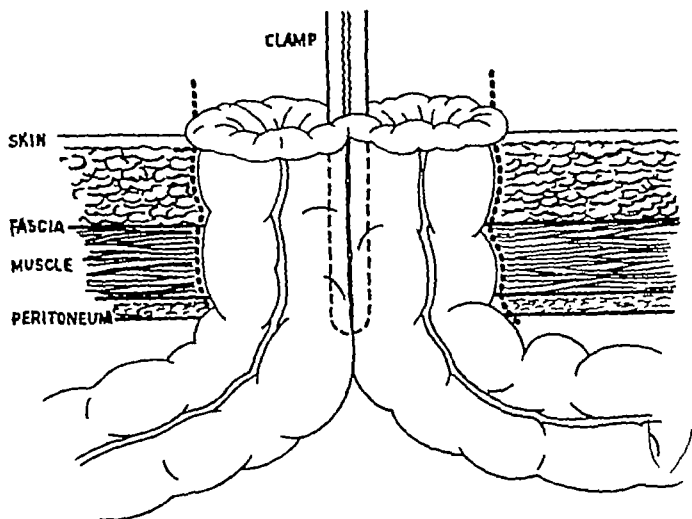


Fig 3—A long thin spur. Crushing clamps are applied to the spur until sufficient channel is produced. Incision represented by the dotted line is carried down to the peritoneum which is partially opened. After closure the bowel is placed in a compartment of the lateral gutter partly excluded from the general peritoneal cavity.

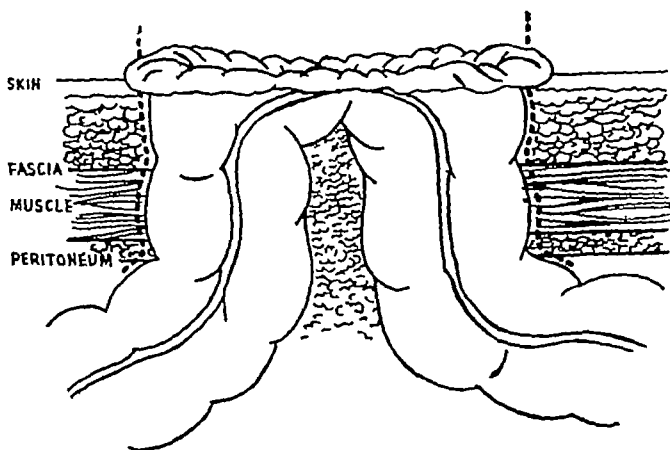


Fig 4—Thick spur or palpable mass between limbs of colostomy makes application of clamps to septum dangerous. Incision, represented by dotted line is carried down into the peritoneal cavity. Limbs of bowel are mobilized and separated. Anterior half open portion of the colon is closed as an end-to-end anastomosis.

margins of the stoma in a transverse direction. This is, in effect, applying end-to-end anastomosis to the anterior half of the lumen of the colon. In one patient a palpable mass, thought to be between the two limbs of the colostomy, proved at operation to be a small abscess just lateral to the septum. In this case immediate suture was abandoned, clamps were placed on the spur under direct vision, the peritoneum and fascia sutured, and the skin packed open. Subsequent closure of the colostomy carried out after an interval of two months resulted in primary union.

As illustrated in Fig 5, a particularly difficult situation is encountered, when a portion of exteriorized bowel retracts or sloughs out beneath the skin. In such cases an abscess forms in the layers of the abdominal wall. With the scarring attendant upon healing of the abscess cavity, the lumen of the colon becomes constricted by a band of scar tissue, and the bowel is adherent to the fascia of the abdominal wall. Palpation reveals no spur, and a very narrow, inadequate lumen. In dealing with the problem presented we have opened the

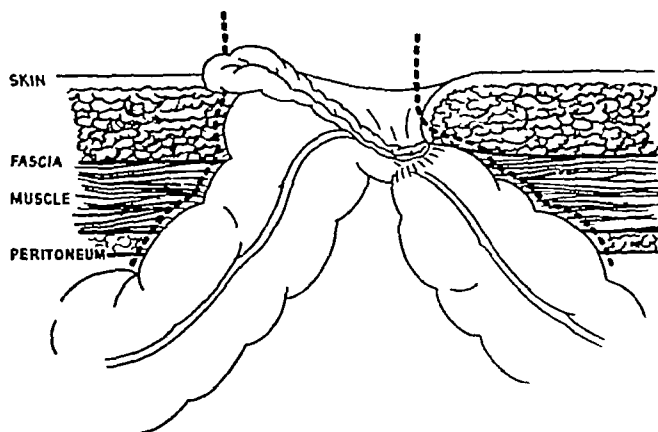


Fig 5—One limb of the colostomy has retracted beneath fascia resulting in abscess with subsequent constriction of the distal loop. Primary incision represented by dotted line is carried into the peritoneal cavity. Limbs of the colostomy are mobilized. The scar is excised. Distal lumen is split longitudinally on its antimesenteric border. Suture of the bowel is transverse to its long axis.

peritoneum widely, mobilized the stoma limbs, and freed the scar from the bowel from the adherent fascia. Then we have carefully excised the scar from the wall of the colon and opened the constricted lumen on its antimesenteric border in a longitudinal direction. Suture of the resulting opening in the colon in a transverse direction has resulted in an adequate lumen. As we have observed colostomies in this general hospital, this type of case presents the only problem which might require resection of the stoma and end-to-end suture, and then only if the procedure which has been described fails to give adequate lumen.

Of our twenty-three patients, the peritoneum was opened widely in nine, partially opened in thirteen, and avoided completely in one. Crushing of the spur was employed in fourteen.

Of the twenty-three colostomies closed using the principles of technique and chemotherapy as described, nineteen healed completely by primary union.

at fourteen days three developed serious or sanguineous drainage which delayed healing longer than two weeks, and one developed infection in a subcutaneous hematoma. There were no fecal drainage, no deaths, no failure. Two postoperative complications occurred, neither related to the closure. One patient showed signs of small bowel obstruction on the fourth day following closure of the enteric stoma, after having had a normal bowel movement on the third postoperative day. The obstruction proved to be due to an adhesion at the site of the previous small intestinal suture. A severe jaundice, probably of the homologous serum type, revealed itself in the second patient on the fifth postoperative day. Since all our patients were returned to the United States as soon as their wounds healed, follow-up study as to the possible development of late stricture was impossible. All were asymptomatic on discharge from our care.

DISCUSSION

Since we have no follow-up we cannot speak of end results. Late stricture should be uncommon for three reasons: (1) the immediate postoperative peristaltic action was remarkably smooth, (2) scarring is usually the result of infection, strikingly infrequent in these cases, (3) experience in civilian practice following closure of colostomies in a similar manner revealed that symptoms referable to any suspected narrowing of the lumen of the colon were extremely rare.

Our series, although small, involves most of the problems encountered in colostomy closure. We have adopted the most conservative technique possible for the closure of each colostomy, adapting our technique to suit the type of colostomy with which we were dealing. This policy, together with preoperative, operative, and postoperative chemotherapy, has given us excellent results. If colostomy stomas were all to be resected and continuity re-established by end-to-end suture, as advocated by Keene, we feel sure that the morbidity and mortality would be unnecessarily high. It seems to us that suture of only one-half to two-thirds of the circumference of the large intestine, and that on its antimesenteric border, carries less risk than end-to-end union of the entire circumference. The danger of an inadequate blood supply, of leakage of the suture line at the mesenteric angle, and of an inadequate lumen, all of which are dangers of end-to-end union, are more easily avoided. Even with the newest sulfonamides for enteric use, and the combination of penicillin and oral sulfonamides, there still remain organisms in the intestinal tract, notably some of the nonhemolytic and green-producing streptococci, and members of the aerogenes and proteus groups, which are capable of producing a fatal peritonitis. The presence of these organisms should lead us to prevent the possibility of their free entry into the peritoneal cavity. The peritoneum should be entered in colostomy closure only to prevent tension on the suture line or fixed angulation of the bowel, and to enable accurate closure of the abdominal wall.

The one infection in these cases can be accounted for by technical error. When the skin was sutured the subcutaneous tissue had been insufficiently freed from the fascia. Closure of the skin margins left a potential dead space in which hematoma accumulated and became infected. It should be stressed that serous

or sanguineous drainage occurred in three patients without infection. This drainage might be attributed to the sulfanilamide, but we believe it more logical to give credit to chemotherapy for the sterility of these collections. From the results of our study of secondary suture, it was concluded that utilization of a combination of urea and the sulfonamides, when applied in the abdominal wall, might eliminate some of this serous drainage.

SUMMARY

1 The various types of colostomies encountered in the wounded in a general hospital in the Army, and the surgical treatment of each type is described.

2 A routine plan of management, preoperatively and postoperatively, involving sulfaguanidine in the preparation of the bowel, local sulfanilamide, and penicillin is described.

3 Twenty-three colostomies were closed. Nineteen healed perfectly, three developed serous or sanguineous drainage, and one developed a small subcutaneous abscess. There was no fecal drainage, no death.

4 Emphasis is laid upon merits of the conservative methods of colostomy closure.

REFERENCES

- 1 Coller, F. A., and Vaughan, H. H. Treatment of Carcinoma of the Colon, *Ann Surg* 121: 395-408, 1945.
- 2 Dixon, C. F., and Benson, R. F. Closure of Colonic Stoma, Improved Results With Combined Succinylsulfathiazole and Sulfathiazole therapy, *Ann Surg* 120: 562-571, 1944.
- 3 Keene, C. H. Colostomies, *Bull U S Army M Dept* (No 86) 115-117, 1945.
- 4 Pemberton, J. J., and Black, B. Delayed Closure of Incision Made at Closure of Colonic Stomas, *Surg, Gynec & Obst* 76: 385-390, 1943.

EXPERIMENTS IN ULCERATIVE ENTERITIS

FAILURE TO PRODUCE IT BY MESENTERIC LYMPHATIC OBSTRUCTION*

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REICHERT and Mathes¹ in 1936 reported that a condition similar to regional ileitis, described by Crohn, Ginzburg, and Oppenheimer,² could be produced by lymphatic obstruction. In their hands, intestinal lymphatic obstruction produced in the dog some of the changes seen in regional enteritis in man. They injected the subserosal and the mesenteric lymphatics with irritating or sclerosing materials, with or without the additional injection of bacteria, and observed a thickening of the bowel wall but, unlike regional ileitis in man, no mucosal ulcerations were found. Poppe,³ using the method of Reichert and Mathes, reported on the actual production of ulcerative colitis in dogs by the obliteration of intestinal lymphatics and lymph nodes, with or without the additional intravenous injection of bacteria. We have been interested in producing intestinal mucosal ulcerations in dogs in order to study the effectiveness of various methods of therapy in this condition. We have repeated Poppe's work and, while we have not achieved his results, we believe we can explain the discrepancy.

METHODS

We followed Poppe's method of mechanical obliteration of the intestinal lymphatics, the additional intravenous injection of bacteria was not employed, because Poppe observed ulceration of the colonic mucosa without the latter procedure.

Seven dogs were used in our study. Cream was fed to all animals shortly before surgery, so that injections could be made easily into the distended lymphatics. The obliterating agents used were in three instances soricin 2 per cent, and in one instance sodium morrhuate 5 per cent. Bismuth oxychloride was used alone in three dogs and in conjunction with soricin in another dog. The injections were made into the main lymphatics of the radix mesenterii, into lymph nodes, and subserously at various parts of the mesenteric border of the small and large intestinal tract. The main lymphatics in the duodenoileocecal region of one dog were primarily ligated with silk, to be followed later by the injection of soricin. The postoperative course was smooth and uneventful in all dogs except two, which died twelve and twenty-four hours, respectively, after operation without coming out of the anesthesia. The survival periods of the dogs were as follows: twelve, twenty-four, forty-eight, and forty-eight hours, eight days, five weeks and eight and one-half months. Progress of the experi-

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ments was followed in three dogs by reoperation, during which time further injections were made. All animals eventually were studied at autopsy.

RESULTS

Severe inflammatory reactions with redness and swelling of the entire thickness of the bowel were seen in the four dogs autopsied within forty-eight hours. Three of these dogs had been injected with bismuth oxychloride, the other one with sodium morrhuate. The shorter the time interval between injection and inspection, the greater was the gross inflammatory appearance and the exudation of serosanguineous fluid into the peritoneal cavity. Only in those of our experimental animals that were autopsied or reoperated upon one week or later after injection, no free fluid was found in the peritoneal cavity. This is opposed to the findings of Reichert and Mathes, who did not find free peritoneal fluid in any experiment. There was some redness and swelling in the bowel wall in the dog sacrificed in eight days, but here essentially was seen a loss of transparency of the mesenteric surfaces. In only one instance out of the seven experiments was there ulceration of the mucosa. This occurred in the cecum and it was apparent that the etiologic factor was an arterial thrombosis and not lymphatic obstruction. This was verified by the histologic picture, which showed a hemorrhagic infarct. In all instances was the bowel wall thickened, and the longer the time interval became between the injection and inspection, the less inflammatory and the more fibrotic became the bowel wall changes. Dry, sticky, easily separated adhesions were present in the dogs which survived five weeks to eight and one-half months. In no instance did the dogs develop a bloody diarrhea, constipation, or vomiting. This is opposed to Poppe's observation of severe bloody vomiting and of severe bloody diarrheas, some of the animals dying in hemorrhagic shock.

DISCUSSION

We did not obtain chronic ulcerative colitis in the dog, our results being at marked variance with those reported by Poppe. Mucosal changes were observed only during the acute stage following the injections. They were a part of the generalized inflammatory reaction involving the entire bowel wall, mesentery, and contiguous serous surfaces, and were not ulcerative. Later, as a chronic condition developed, the acute inflammatory reaction subsided and chronic fibrotic changes took its place. We are in doubt as to whether these final fibrotic changes were not a late result of the inflammatory reaction with reduced circulation of blood produced by the agents used, rather than the result of lymphatic obstruction per se. In our animals reoperated upon, lymphatics and lymph ducts filled with white chyle were observed in the regions that had been injected previously. This may mean that it is hardly possible to obstruct all or most lymphatics even with massive injections such as we used. The lymphatic system is more spread out and ramified than any one of the other vascular systems. Our negative results of mucosal ulcerations confirm those of Reichert and Mathes, who also reported no mucosal defects, only a thickening of the bowel. Poppe's positive results may have been due to actual thrombotic obstruction of

arteries and veins Our results were so uniform that we believe that in spite of the relatively small series of seven dogs our conclusions are justified

We feel that the problem of producing ulcerative enteritis in the dog experimentally by lymphatic obstruction is not solved

SUMMARY

Attempts to produce ulcerative enteritis in the dog by partial obstruction of intestinal lymphatic flow failed Bismuth oxychloride, sonicin, and sodium morrhuate injected into the lymphatics of the intestines were used as obstructing or sclerosing agents Acute inflammatory changes in the entire thickness of the bowel wall were seen early after injection, but this receded and only thickening of the bowel wall was seen after several weeks to eight one-half months The mucosa was intact in all instances except in one where an ulcer was overlying a thrombosed cecal artery Poppe's findings of ulcerative colitis in the dog may have been due to vascular thrombosis rather than to lymphatic obstruction

REFERENCES

- 1 Reichert, F L, and Mathes, M E Experimental Lymphedema of the Intestinal Tract and Its Relation to Regional Cicatrizing Enteritis, *Ann Surg* 104 601, 1936
- 2 Crohn, B B, Ginzburg, L, and Oppenheimer, G D Regional Ileitis—a Pathologic and Clinical Entity, *J A M A* 99 1323, 1932
- 3 Poppe, J K Reproduction of Ulcerative Colitis in Dogs, *Arch Surg* 43 551, 1941

THE SPLIT-THICKNESS SKIN GRAFT AS A COVERING FOLLOWING REMOVAL OF A FINGERNAIL

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REGENERATION of an intact fingernail depends on the complete integrity of its radix. When the radix has been damaged the injury is reflected in a faulty nail which may be thicker or thinner than normal, cracked, brittle, flaky, and frequently an excrescence which may be a thorough nuisance to its owner. Such a nail is far better removed and its regrowth prevented by complete destruction of the diseased or injured radix. Simple removal of the nail is not enough, the entire radix must be removed.

It is quite possible that the use of split-skin grafts in this connection has previously been described. However, I have been unable to find any previous reference to it. Removal of the radix destroys all nail growth and it becomes necessary to cover the defect. The application of a split graft on the nail bed meets the situation admirably. The graft really resembles a fingernail and the loss of the nail is apparent only on rather close inspection. This is one site where the difference in color and texture of the graft and that of the surrounding skin is an advantage.

Herewith are illustrated two examples of split grafts which have made very satisfactory substitutes for thumbnails. In one case, on the hand of a dentist, excessive roentgen irradiation had injured both the matrix and the radix of the



Fig 1

Fig 2

Fig 1—Distal joint of thumb injured by excessive exposure to x-ray

Fig 2—A split graft used to cover the defect on the joint of the thumb after removal of damaged nail and radix.

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Fig 3



Fig 4

Fig 3—Distal joint of thumb showing the point of exquisite tenderness.

Fig 4—The thumb shown in Fig 3 after removal of the nail and the radix in which was found a glomus tumor. The bed of the nail has been covered by a split graft.

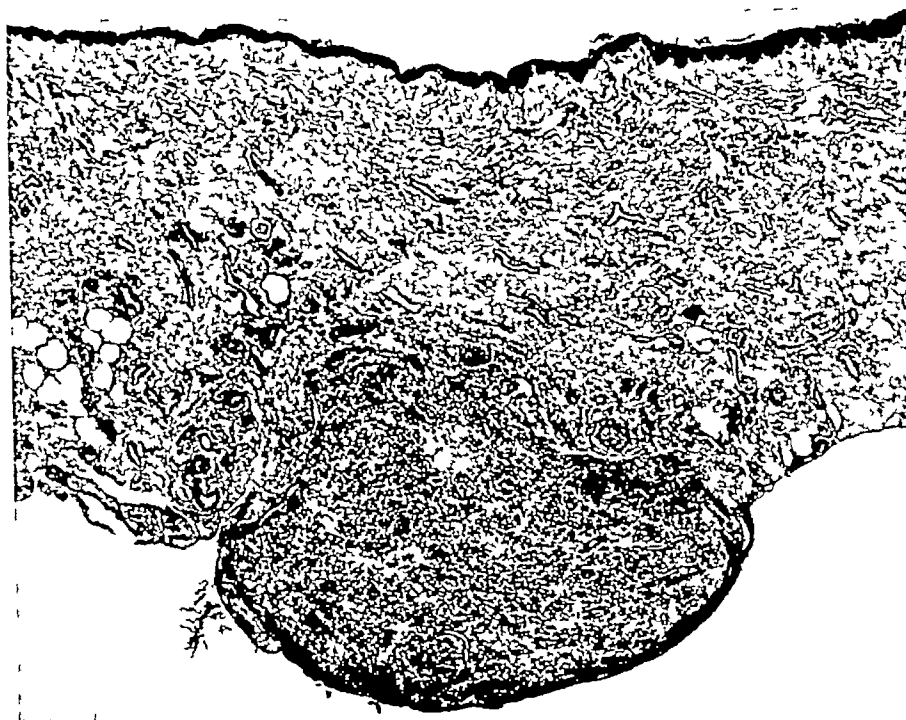
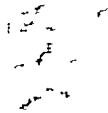


Fig 5—Section through the radix of the thumb nail shown in Fig 3, showing the small glomus tumor which was found on the undersurface of the radix.

nail and brought about the condition shown in Fig 1. The nail and the radix were removed and the defect covered with a split graft taken from the thigh. In the second case the patient complained of an exquisitely painful point just at the base of the thumbnail. His description of the pain was typical of that caused by a glomus tumor. It was decided to remove the nail and since the tumor would undoubtedly be found in the radix to remove that also. Roentgenographs of the terminal phalanx had shown no involvement of the bone. After the nail was removed and a flap of skin turned back at the base of the nail, the radix showed only a faint point of redness on its outer surface. The radix was carefully dissected away from the surface of the bone and the glomus tumor was seen as a 2 mm nodule standing out from the undersurface. The radix was removed and the defect covered as in the first case. Both the subsequent appearance and function have been very satisfactory to the individuals concerned.

Application of the grafts in this locality is not as simple as elsewhere. The fixation is difficult because of hemorrhage. Possibly fibrin fixation might help but I have not used it. Hemorrhage may be controlled by two or three very fine catgut ligatures, by pressure, and by topical thrombin. The graft may be sutured around the margin of the defect with continuous nylon and several interrupted nylon sutures tied over a small piece of xeroform gauze placed directly on the graft. Considerable comfort may be gained by using a small curved metal splint for the ball of the thumb and exerting pressure on the graft by bandaging over a fine-grade marine sponge. The hand should be kept elevated on pillows for at least twenty-four hours and in a sling during the remainder of the healing period. The aftercare is as usual for this type of graft.



Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M D

ACTINOMYCOSIS

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THE TREATMENT OF EXTENSIVE ACTINOMYCOSIS

OUR interest in the problem of the treatment of extensive actinomycosis was aroused by a case of advanced abdominal actinomycosis occurring in a young girl. Over a period of several months, the progress of the disease was arrested, the patient rehabilitated to a normal life, and probably cured. A review of the hospital records revealed that although the results in the treatment of mild or early cases of actinomycosis using a variety of therapeutic agents were good, the treatment of advanced cases of actinomycosis was uniformly unsuccessful. With this in mind, the case records have been carefully examined and compared, and a review of the literature has been made. The collected information has been used as a basis for an evaluation of the treatment of extensive actinomycosis.

History—In 1877, Bollinger¹⁶ reported that he had found branching mycelia in the material from a diseased jawbone of a cow. He considered them to be the causative agents of this condition. This organism was named *Actinomyces* or the "ray fungus" by Halz⁶⁷. At this same time Israel⁸² described the organism as found in human autopsy material. The disease was first recognized clinically by Ponfick¹³⁸ in 1879. In 1885, Israel⁸³ reviewed thirty-eight cases of actinomycosis and clearly defined the disease as a clinical entity. The first careful studies of the etiology and pathogenesis of actinomycosis were carried out by Bostroem¹⁷ and by Wolff and Israel¹⁸².

Etiology—The organisms causing actinomycosis belong to the *Actinomycetes*. These microorganisms are gram positive and are characterized by the formation of a mycelium or network of branched filaments. Waksman¹⁷² considered them to be an independent group of organisms closely related to the true bacteria which had developed a funguslike form of growth. The organisms of this group are closely related to the tubercle bacillus, the leprosy bacillus, and the diphtheroids^{10, 169}. The members of this group live in the soil, on grains and grasses, and in water⁷¹. Several species are pathogenic for plants, for example, potato scab. Only a very small number of these organisms are pathogenic for man and animals.

On the basis of their oxygen requirements, the actinomyces may be divided into an aerobic group and an anaerobic or microaerophilic group. The aerobic

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group is almost entirely composed of harmless vegetable saprophytes Naeslund,¹²⁷ in a survey of 500 different strains of aerobic actinomyces, found only two which produced actinomycosis in experimental animals. The anaerobic or microaerophilic group, on the other hand, is composed almost entirely of pathogens. Using their oxygen requirements as a basis of classification Waksman and Henrici¹⁷³ have arranged the pathogenic actinomyces into the genus *Actinomyces*, which contains the microaerophilic and anaerobic pathogens, and the genus *Nocardia*, which contains the aerobic pathogens. Organisms of both genera will produce actinomycosis in man (Slack,¹⁵⁹ Rosebury and associates,¹⁴⁹ Lord,¹⁰⁰ ¹⁰¹ and Naeslund¹²⁷)

Pathogenesis—There have been two main concepts of the pathogenesis of actinomycosis. Bostroem¹⁷ believed that actinomycosis was due to an infection with aerobic actinomyces found in the environment and, therefore, was an exogenous infection. Wolff and Israel¹⁸² believed that the disease was caused by anaerobic actinomyces, which could not be readily isolated from the environment, and considered the disease to be endogenous in origin.

Bostroem held that human actinomycosis was associated with bovine actinomycosis and that human infections occurred either directly by contact with diseased animals or indirectly through the mediation of contaminated vegetable fomites, that is, straws, grasses, etc. For many years these were considered to be the most important modes of infection and clinicians laid stress upon a history of contact with animals with "lumpy jaw," a habit of chewing straw or stalks, and a rural habitat. Naeslund¹²⁷ and Erikson⁵⁰ have shown that only a very small number of the aerobic actinomyces found in nature are pathogenic. Aerobic actinomyces have been isolated from the mouth.¹⁸ As will be shown later, a history of contact with so-called actinomycotic animals is of little importance unless the exact nature of the disease in animals is known. Analysis of reported cases has shown actinomycosis to be as common in cities as in rural areas. Aerobic infections occasionally occur as attested by the reports of Naeslund,¹²⁷ Erikson,⁵⁰ and Biggart.¹⁴ Benbow, Smith, and Grimson,⁹ reporting on cases of pulmonary actinomycosis due to aerobic organisms, estimate that 10 per cent of pulmonary actinomycosis is caused by aerobic infection. Naeslund¹²⁷ believed that aerobic infections were most common in the chest or in cases with metastatic foci. It must be concluded, however, that exogenous infections with aerobic actinomyces (*Nocardia*) form only a small minority of actinomycotic infections.

By far the largest share of actinomycosis is produced by anaerobic or microaerophilic actinomyces (*Actinomyces*)⁵¹ and may be considered as endogenous infections, the concept promulgated by Wolff and Israel. It was Naeslund's impression that the anaerobic actinomyces were associated with actinomycosis of the gastrointestinal tract and tissues in juxtaposition to the gastrointestinal tract. The normal habitat of the anaerobic actinomyces is in the oral cavity. Lord,¹⁰⁰ ¹⁰¹ Emmons,⁴⁵⁻⁴⁷ and Slack¹⁵⁹ have isolated pathogenic actinomyces from the tonsils. Davis,³³ however, has called attention to the fact that all tonsillar granules are not actinomycotic. *Actinomyces* have been isolated from pyorrhea pus, dental scum, salivary calculi, and the contents of

carious teeth by Slack,¹⁵⁰ Lord and Tievett,¹⁰² Rosebury and associates,¹⁴⁹ and Sullivan and Goldsworthy¹⁶⁰ Using these organisms, the pathologic picture of actinomycosis has been produced in animals by Slack,¹⁵⁰ Rosebury and associates,¹⁴⁹ Lord,¹⁰¹ and Naeslund¹²⁷

The relationship of dental caries to actinomycosis was first noted by Lord,^{100 101} who stated that under certain conditions persons with carious teeth were hable to develop actinomycosis Axhausen³ and Sullivan and Goldsworthy¹⁶⁰ have noted that the acute form of facial actinomycosis not infrequently follows exodontia Israel reported a case (cited by Naeslund) in which pulmonary actinomycosis followed the aspiration of a tooth At autopsy, the center of infection was found to contain fragments of the tooth Colebrook²⁸ and Robinson¹⁴⁷ have reported cases of actinomycosis of the hand and arm following human bites In Table I is illustrated the coincidence of dental sepsis in thirty-nine cases of actinomycosis which we are reporting here

TABLE I COINCIDENCE OF ORAL SEPSIS WITH ACTINOMYCOSIS

TYPE	NUMBER OF CASES	ORAL SEPSIS PRESENT
Cervicofacial	16	15
Lingual	2	2
Abdominal	14	6
Thoracic	7	2

Minor trauma, inflammation associated with root abscesses or exodontia, may afford the opportunity for the actinomyces to become invasive The actinomyces in the oral cavity are probably carried into the gastrointestinal tract by the act of deglutition From this point, we know nothing of their progress through the intestinal tract It may be inferred from clinical observations, however, that in some cases the organisms are retained in the cecum or in diverticula in the colon Actinomyces from the oral cavity may gain admittance to the tracheobronchial tree by aspiration The aerobic actinomyces, occurring widely in the environment, have rarely been reported in the mouth^{13, 50} They may reach the lungs through the respiratory tract The pathogenesis of aerobic infections is unknown

Axhausen³ has stressed the importance of pyogenic cocci in initiating cervicofacial actinomycosis Wright¹⁸⁵ believed that only a small number of actinomycotic infections were pure infections with specific organisms Naeslund¹²⁷ felt that mixed infections were of significance only in producing a more rapid spread of the infection and a greater inflammatory reaction by the tissue Wangenstein¹⁷⁸ believed that the concomitant bacterial invaders, by reducing the oxygen potential of the tissue, aided in producing the required anaerobiasis for the growth of the Actinomyces The role of specific bacterial synergists is unknown Although *Actinobacillus actinomycetem comitans*⁵ is found only in the lesions of actinomycosis, the disease has been produced in animals with pure cultures of the actinomyces

The importance of tissue sensitivity in relation to the production of actinomycosis was pointed out by Hemmer and his group¹¹⁶ They were able to produce actinomycosis in animals by repeated inoculations with small num-

ber of actinomyces over a period of weeks. The possibility exists that a patient harboring pathogenic actinomyces in the oral cavity may by the process of repeated exposure develop sufficient sensitivity to the organisms or their products so that an allergic reaction itself might provoke an inflammatory reaction of sufficient intensity to allow the actinomyces to gain a foothold in the tissue.

The actinomyces themselves are not actively motile. Extension of the infection occurs through the activity of the macrophages which carry the filaments out into the surrounding tissue.¹⁸ The inference may be drawn that an inflammatory reaction must be present before an actinomycotic infection can become established. In cervicofacial infections, this inflammatory nidus is probably furnished by the presence of dental sepsis or exodontia. The frequent association of abdominal actinomycosis with appendicitis and diverticulitis indicates an inflammatory mechanism by which the organisms may gain access to the retroperitoneal tissues. The frequency of mild inflammatory processes in the chest can give ample opportunity for the infection to become established.

Pathology—Histologically the lesions of actinomycosis represent a chronic suppurative process. The organisms occur either as dispersed mycelia or collected in the characteristic granules. The granules are composed of radially arranged masses of branching mycelia. In sections stained with the Gram stain, the granules have a central portion consisting of mycelial threads which are Gram positive and a peripheral zone of mycelial clubs which are Gram negative. The granules are surrounded by a collection of polymorphonuclear leucocytes, small round cells, and mononuclear cells. On the periphery of the cellular exudate there is a marked fibroblastic reaction. When granules cannot be demonstrated, the infected tissue shows only a nonspecific type of chronic inflammation.

The incubation period of actinomycosis cannot be determined with accuracy. The infection begins in the subcutaneous, submucous, or subperitoneal connective tissue as a small area of brawny or "wooden" induration. Following the stage of induration there is a progressive erosion of the connective tissue. The overlying skin breaks down with the formation of multiple sinuses which drain a seropurulent discharge containing the characteristic sulfur granules. Spread through the blood stream is uncommon, but a lesion may rupture into a vessel and give rise to metastatic foci in distant organs. Actinomyces have been obtained by Northrop and Crowley¹³ in pure culture from the blood stream immediately following exodontia. Extension through the lymphatics occurs only rarely and the entire lymphatic system enjoys a surprising degree of immunity. The infection tends to spread beneath, but not across, epithelial or endothelial barriers. The peritoneum is quite resistant to attack, large masses of actinomycotic tissue may form behind the peritoneum without perforating into the abdominal cavity. The pleura does not have the same powers of resistance and is commonly involved in thoracic actinomycosis.

Clinical Aspect—Actinomycosis is a chronic disease affecting man and animals characterized by the formation of granulomatous tumors usually associated with multiple fistulas to the overlying skin, which drain a seropurulent discharge containing yellow granules. Actinomycotic lesions have been reported from all parts of the body but are commonly situated in the cervico-facial, thoracic, and abdominal regions (see Table II)

TABLE II THE SITUATION OF ACTINOMYCOTIC LESIONS

AUTHOR	NUMBER OF CASES	CERVICO FACIAL (%)	THORACIC (%)	ABDOMINAL (%)	MISCELLANEOUS* (%)
Sanford and Voelker ¹⁵¹	670	60	14	18	8
Cope ³⁰	1,330	57	15	22	5

*For a discussion of these cases see Cope³⁰ and Orr¹³⁰

The incidence of actinomycosis is difficult to estimate. In the years 1930 to 1936, the average number of reported deaths due to the disease in the United States was just over sixty. The number of reported cases has been rising slowly during the past twenty-five years due to more accurate diagnosis. Cope³¹ believed that the number of reported cases depended upon the acumen of the diagnosticians, an opinion supported by the work of Sanford.¹⁵⁰ The world-wide distribution of actinomycosis is shown in Fig. 1. In the United States, the greater number of reported cases have come from the North Central States. Sanford, however, believed that the increased incidence in this region was apparent rather than real and was due to more accurate diagnosis. Cope and Sanford were unable to find any increased incidence of the disease in rural areas. Occupation seemed to be of no significance. In an analysis of 670 cases of actinomycosis, Sanford and Voelker¹⁵¹ found that the median age incidence fell between 20 and 30 years. Eighty per cent of the patients were men.

The clinical picture of actinomycosis in man and animals may be produced by three different microorganisms: some actinomyces (actinomycosis), a staphylococcus (botryomycosis),^{41, 112} and an actinobacillus (actinobacillosis).⁹⁹ Botryomycosis and actinobacillosis occur infrequently in man, but are common in animals.¹¹¹ Actinomycosis occurs frequently in both man and animals.

The differential diagnosis of these diseases in animals is important as it affects the theory of the etiology and the rationale of the treatment of actinomycosis in man. The studies of Magnusson,¹¹¹ Griffith,⁶¹ and Shahan and Davis¹⁵⁸ indicate that only a fraction of all of the animals with a clinical diagnosis of actinomycosis suffer from this disease. It follows from this that a history of contact with so-called actinomycotic animals is of little significance in human actinomycosis unless the nature of the disease in the animal is conclusively determined. Simple gram stains of the granules found in these conditions may be used to differentiate them accurately and a positive diagnosis of actinomycosis can be made from a single typical granule.

The importance of cultural methods in the diagnosis of actinomycosis lies in the differentiation of the aerobic actinomyces (*Nocardia*) from the micro-

aerophilic or anaerobic actinomyces (*Actinomyces*) Successful isolation of the organisms is quite difficult under any circumstances and in old chronic lesions it is almost impossible to separate the primary organisms from the

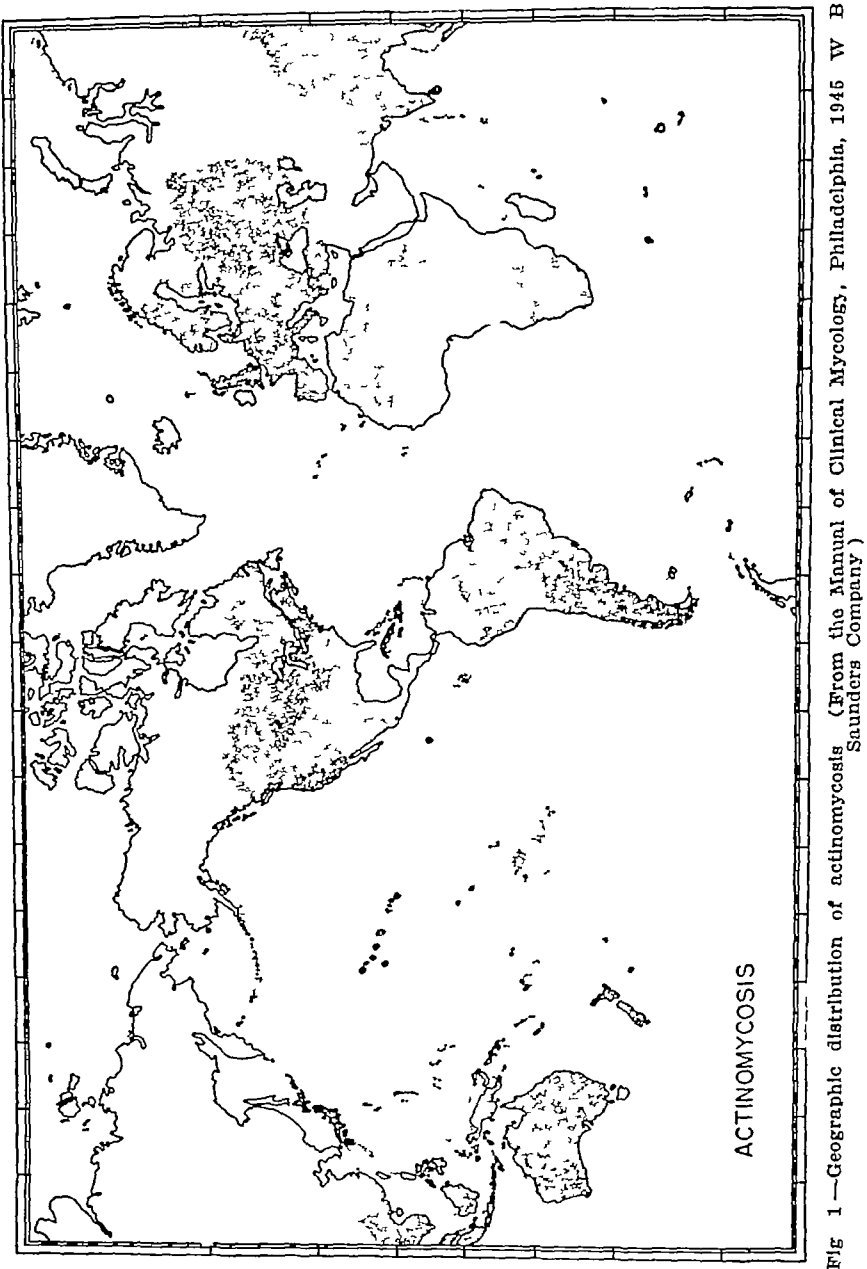


Fig 1—Geographic distribution of actinomycosis (From the Manual of Clinical Mycology, Philadelphia, 1945 W B Saunders Company)

host of secondary invaders Attempts at culturing the organisms are most successful in recent lesions which are being incised for the first time The cultural techniques used for the isolation of actinomyces have recently been reviewed in a publication of the National Research Council ¹¹⁸

The classic picture of cervicofacial actinomycosis is the slow onset of swelling and induration with sinus formation although Axhausen³ has pointed out the importance of recognizing the acute forms of the disease. The mortality in cervicofacial actinomycosis is due to the involvement of vital tissue by extension from the original site of infection. In order to determine the prognosis of cervicofacial infections and to evaluate the treatment more accurately, we have divided them into three types, depending upon the degree of localization or extension at the time treatment is instituted. Type 1, a circumscribed abscess or area of induration without sinuses, Type 2, lesions with sinuses but not invading vital structures, Type 3, lesions extending into the orbit, sinuses, spine, or mediastinum. The prognosis with the first two types is usually good. Lesions of the third type usually terminate with an actinomycotic meningitis or with thoracic involvement.

Thoracic actinomycosis may be primary or secondary. Secondary involvement may be due to extension from the cervical region or from the abdomen. In these cases the primary lesions usually indicate the diagnosis. Primary thoracic actinomycosis presents much more of a diagnostic problem, being similar in many ways to other forms of chronic pulmonary suppuration. Naussac¹²⁸ has classified pulmonary actinomycosis into three anatomic divisions: (1) bronchoactinomycosis, (2) pleuropneumoactinomycosis, and (3) pneumoactinomycosis. Fever, cough, and expectoration are common to all types. Hemoptysis is rare. Depending upon the type of infection, the symptoms may be predominantly those associated with a bronchitis, a pulmonary effusion, an empyema, or a pulmonary consolidation. The diagnosis can be made by demonstrating sulfur granules in the sputum or pleural fluid. Periostitis of the ribs associated with nonspecific changes in the lung may lead to the roentgenologic diagnosis.⁹³ Empyema necessitatis is frequently the presenting symptom in thoracic actinomycosis.

Abdominal actinomycosis shows a predilection for the right lower quadrant and frequently follows operations for acute appendicitis or drainage of abscesses in this region. Occasionally it is associated with diverticulitis of the colon. Any draining sinus on the abdominal wall should be carefully examined to exclude actinomycosis. The presence of a fecal fistula in a patient with abdominal actinomycosis indicates a grave prognosis. In order to make a more accurate estimate of the prognosis of abdominal actinomycosis, Morton¹²³ has divided them into three groups: (1) those resembling acute appendicitis with a residual sinus tract, (2) those presenting a mass in the right lower quadrant without signs of obstruction, and (3) those associated with psoas spasm or a flexed thigh.

Treatment—The history of the treatment of actinomycosis simulates that of all infectious diseases. Groping through the available therapeutic armamentarium following current fads, physicians have employed surgery, chemotherapy, vaccines, irradiation, and latterly the current chemotherapeutic panaceas, the sulfonamides, and penicillin, in an effort to cure the disease. The popularity of the various forms of treatment has waxed and waned. The results of treat-

ment have been variable. The number of remedies attests to the lack of uniform success with any one of them. A review of the literature reveals many ambitious claims for all. Because the chronicity of the disease made it possible for many forms of treatment to be used successively or simultaneously, the evaluation of any single therapeutic agent is difficult. The lesions have only rarely been classified as to extent, making the results of treatment difficult to compare. In general, the fact evolves that cervicofacial and other circumscribed actinomycotic lesions have been amenable to treatment with the majority of the methods tried. This is in contrast to the relative incurability of the abdominal disease and with the exception of isolated cases, the almost inevitable mortality in thoracic actinomycosis.

A list of the larger series of cases of actinomycosis treated by various methods has been gleaned from the literature. These include the majority of the important papers dealing with the treatment of actinomycosis, but the list is by no means complete. Combinations of treatment have been used by most authors reporting. Adjuvant potassium iodide is the most common. Each author, however, relied mainly on one form of therapy and considered the success of his treatment to be due to that agent. A summary of authors, types of cases, and results has been appended to the discussion of each form of therapy.

Surgery—Incision into and drainage of collections of pus is one of the most ancient surgical remedies. No doubt, long before actinomycosis was described as an entity surgeons were draining the abscesses associated with the disease. The exact history of the establishment of the surgical treatment of actinomycosis is difficult to trace. The search for other methods of treatment in the disease early in its history suggests that the results of incision and drainage of actinomycotic lesions were not attended by favorable results. The proper effective surgical treatment gradually evolved from the experience gathered in the treatment of the disease. As far as we can determine, the principles were first clearly stated in 1905 by Waring,¹⁷⁰ a British surgeon. This man cured four of seven cases of abdominal actinomycosis originating in the right lower quadrant by means of surgery and adjuvant potassium iodide therapy. He wrote, "The limits of surgery appear to be incision, evacuation, scraping, draining of abscesses immediately they can be diagnosed, and afterwards repeated irrigation with an antiseptic solution, with iodine or better, with a solution of peroxide of hydrogen. The latter chemical agent appears to be the most effective agent in arresting the local growth of the parasite." This paper established the proper technique for the surgical treatment of actinomycosis. The factor of meticulous local wound hygiene was emphasized by Smith,¹⁶¹ and we feel that it is exceedingly important. Colebrook²⁹ in 1921 amplified Waring's principles in his paper on vaccine therapy, and he prophesied the possibility of success in extensive thoracic and abdominal actinomycosis with radical surgical management. Brickner¹⁸ of New York reported in 1925 that he had cured five patients suffering with severe low abdominal and pelvic actinomycosis by means of radical incision, excision, and curettage followed by oral potassium iodide and the local application of Lugol's solution.

Wangensteen, after observing many patients with actinomycosis, unsuccessfully treated with conservative methods, turned to surgery. In 1936, reporting his success in the surgical treatment of actinomycosis, he¹⁷⁸ emphasized that radical surgery per se is the sine qua non of the treatment of extensive actinomycosis. He concluded "The most direct agency in the treatment of actinomycosis is surgery. The rationale of the surgical treatment lies in the fact that the infection is essentially an anaerobic one. Removal of the dead tissue, which is poorly oxygenated and is in consequence an excellent culture medium, will usually terminate the disease." He relied mainly on the removal of dead tissue by repeated curettage. He considered the prognosis of advanced cases of abdominal and thoracic actinomycosis to be poor.

A tabulation of the results of the surgical treatment of actinomycosis will be found in Table III.

TABLE III RESULTS OF SURGICAL TREATMENT OF ACTINOMYCOSIS

AUTHOR	DATE	THERAPY	TYPES OF CASES AND RESULTS														
			CERVICOFACIAL					THORACIC					ABDOMINAL				
			O	C	I	D	N	O	C	I	D	N	O	C	I	D	N
Gangolphe and Duplant	1897	S, P											1		1		
Bell ⁸	1905	S, P, Si	3	3				1			1		4	1		3	
Choyce ²⁴	1910	S, P											1		1		
McKenty ¹⁰⁹	1913	S, P	19	15		0	4	2			2		11	2		9	
Cope ³⁰	1915	S, P	6	4	2			3			3		2		1	1	
Ramstad ¹⁴²	1916	S, P	4	3		0	1	1				1	1			1	
Ochsner ¹³⁴	1917	S, P											1		1		
McCallen ¹⁰⁶	1919	S, P	4	1	1	2(?)							2	1			1
Matz ¹¹⁷	1922	S											7	4		3	
Brockman ²⁰	1922	S, P, V											4			4	
Brickner ¹⁹	1925	----											5	5			
Smith ¹⁶¹	1930	S											7		5	2	
Wangensteen ¹⁷⁷	1932	S, P						1	1								
Pope ¹³⁹	1935	S, X*	10	10				1			1		2			2	
Ellis ⁴⁴	1935	S						2		1	1		3			3	
Bisgard ¹⁵	1938	S, P, X						2	2								
Schmitt and Olson ¹⁵⁵	1941	?						2			1	1					
Randall ¹⁴⁴	1942	S	16	12		1	3										
Ziskin et al ¹⁸⁷	----	S, P, X	17	11	4	2		4		1	3		5	1		4	
U. of Minnesota Surgical Dept [†]	----	S, P, X, Sn	17	10	3	4		7			7		14	1		13	
Totals			96	69	10	9	8	26	3	2	19	2	70	15	9	45	1

S Surgery
P Potassium iodide
X X-ray
Sn Sulfonamide
O Number of cases
C Number of patients cured
I Number of patients improved
D Number of deaths
V Vaccine
N No follow-up
Si Silver nitrate.

*X-ray therapy was added to surgical treatment in three cases of Pope's series.

†Includes cases reported by Wangenstein¹⁷⁷, ¹⁷⁸ and Randall¹⁴⁴.

Potassium Iodide—Potassium iodide was introduced empirically by Thomassen¹⁶⁸ in 1885 for the treatment of lingual actinomycosis of cattle. Nocard¹³¹ championed the drug and stimulated its introduction in the treatment of human actinomycosis by Ittersen and Netter⁸⁴ in the same year. In spite of the optimistic recommendations and the success attending the use of potassium iodide in other granulomatous diseases (for example syphilitic gummas), its

therapeutic ineffectualness in both bovine and human actinomycosis was soon obvious Harbitz and Grondahl⁶⁴ and later Henrici⁷² found in in vitro studies luxuriant growth of actinomyces in media containing 2 per cent potassium iodide Clinical experience fortified by these studies established the inutilty of potassium iodide therapy in actinomycosis An interesting sidelight on the history of potassium iodide therapy in actinomycosis is related to Thomassen's success with what he thought was lingual actinomycosis As first described by Lignieres and Spitz⁹⁹ and shown by Griffith⁶¹ and others,^{111, 158} granulomatous lesions of the bovine tongue are usually due to actinobacillosis which is specifically amenable to potassium iodide therapy The universal application of potassium iodide to human actinomycosis is an example of a world-wide medical hebetude resulting from Thomassen's ignorance of the bacteriology of the disease he treated At the present time, enlightened clinicians share the opinion of Colebrook,²⁹ Jungling,⁸⁷ and Wangenstein¹⁷⁸ that reliance upon potassium iodide for the treatment of actinomycosis is not warranted and that at the present time no indications for its use exist

Copper Sulfate—Copper sulfate was introduced by Bevan¹² in 1905 for the treatment of actinomycosis as an adjuvant to surgical drainage He was influenced by the experience of agriculturists who had found this chemical an effective fungicide for grains contaminated with molds The drug was administered orally and the sinus tracts were irrigated with a 1 per cent solution Several authors used copper sulfate in their shotgun approach to the treatment of actinomycosis Von Baracz¹⁰ treated successfully thirty out of thirty-six patients with actinomycosis by the parenchymatous injection of copper sulfate solution His cured patients had cervicofacial disease, while two with abdominal disease died and four were still under treatment at the time of his report

Other chemotherapeutic methods employing the arsenicals, methylene blue, and iodine- iontophoresis are scattered through the literature, but are not of sufficient importance to warrant detailed discussion

X-ray and Radium Irradiation—The radiation therapy of actinomycosis was introduced by Harsha⁶⁶ in 1904 At the Chicago Surgical Society, he reported a case of cervicofacial actinomycosis which was cured by means of combined potassium iodide and x-ray irradiation By 1905 Bevan¹¹ had treated six patients with irradiation In 1916, Heyerdahl⁸ of Oslo reported a cervicofacial case cured by radium emanations and by 1919 had reported success in six cases⁷⁷ An incomplete review of the literature is summarized in Table IV The number of authors reporting attests to the popularity of this method of treatment

Employed initially with potassium iodide, it was thought that the x-rays caused the release of nascent iodine which killed the actinomyces in the lesions Jungling⁸⁷ and others have shown that irradiation is effective in the absence of adjuvant potassium iodide Kleesattel⁹⁴ subjected pure cultures of pathogenic actinomyces to irradiation He found that they tolerated up to ten erythema

TABLE IV RESULTS WITH RADIATION THERAPY OF ACTINOMYCOSIS

AUTHOR	DATE	THERAPY	TYPES OF CASES AND RESULTS														
			CERVICOFACIAL					THORACIC					ABDOMINAL				
			O	C	I	D	N	O	C	I	D	N	O	C	I	D	N
Harsh ⁴⁶	1904	X, P	1	1													
Beran ¹¹	1905	X, S, P	1	1				1		1			4	0	3	1	
Leri ⁹³	1913	X	3	3													
Sardemann ¹⁵²	1914	X, S	4	4													
Nordentoft ^{13*}	1914	X	2	1		1											
Schmidt ¹⁵⁴	1915	X, P	1	1													
Heyerdahl ^{16, 18}	1916																
	1919																
	1927	R	21	21													
Melchior ¹¹⁸	1916	X, P	3	3													
Dittrich ³⁶	1920	X, S, P	21	19	2	0											
Stenkamm ¹⁶³	1921	X	3	3													
Jungling ⁸⁷	1920	X, S, P	12	11		1											
Prikul ¹⁴¹	1921	X, S	1	1													
Brofelt ⁴¹	1922	X, S	87	67			20	15			15		49	22		27	
Brogden ²	1922	X, S, P, Co											14	2	3	6	3
Beck ⁶	1922	X, Ne, FP											2	2			
Sattler ¹⁵³	1923	X, S, P											3	2		1	
Wakeley ¹⁷¹	1923	X, S, P	4	3		1		3			3		2	2			
New and Fig ¹³⁰	1923	R, S, P	85	60	18	7							2	2			
Kaplan ⁸⁸	1924	R, S											1	1			
Brunzel ⁷³	1925	X	1	1													
Eiken ⁴³	1926	X, S, P	3	2	1								1	1			
Grünthal ⁶²	1927	X											1	1			
Tempsky ¹⁶⁷	1927	X, P	36	32			4	4	1		3		3		1	2	
Desjardins ²⁵	1928	X, S, P						7			6	1					
Heeren ⁶⁸	1929	X	12	8	2	2		3			2	1	23	1	5	17	
Good ⁵⁹	1930	X, S, P						13		1	6	6	1			1	
Good ⁶⁰	1931	X, P											55	8	6	29	12
Stocker ¹⁶⁴	1931	X, P	15	9		3	3	5		1	2	2	2	1			1
Engelstad ^{48, 49}	1932	R	28	25	1	1	1										
	1933	R											1	1			
Harrison ⁶⁵	1934	X	22	22				4			4		4			4	
Smith ¹⁶⁰	1934	X, S	7	5	2												
Masson ¹¹⁵	1936	X, P											2	2			
Martin ¹¹⁴	1936	X	3	3													
Keijser ⁹²	1936	X, P	69	64	3	2		3			3		27	9		18	
Weysser ¹⁸⁰	1937	X											1			1	
Kuhlmann ⁹⁸	1937	X, P											1			1	
Renander ¹⁴⁵	1937	X	31	26		5		4			4		13	5		8	
McWhirter ¹¹⁰	1938	X	8	7	1			2	1	1			4	3	1		
Starlinger ¹⁶²	1938	X, L, P											1	1			
Haldre and Koskvee ⁷⁹	1941	X, P	120	87		10	23	4	1	1	2		17	9	2	6	
Henkel ⁷⁰	1941	X, P											2	2			
Totals			604	490	30	33	51	72	3	5	53	10	234	75	21	122	16

X, X ray
R, Radium
P, Potassium iodide
S, Surgery
Co, Copper SO₄
Ne, Neoparsphenamine

FP, Foreign protein
L, Lymph extract
O, Number of cases
I, Number of patients improved
C, Number of patients cured
D, Number of deaths
N, No follow-up

skin doses, a quantity infinitely greater than the amount employed in clinical therapy. He concluded that the effects of irradiation therapy in actinomycosis were nonspecific. Smith¹⁶⁰ theorized that either the actinomyceete in vivo was more susceptible to irradiation than in vitro or the effectiveness of irradiation therapy resulted from the destruction of synergistic organisms in the actinomycotic lesions which enabled the natural defenses of the body to cope

with the actinomyces present. At the present time, clinical results prove the effectiveness of irradiation therapy in actinomycosis but the mode of action is unknown.

Extreme variations in therapeutic irradiation technique have been described with similar results attending most of them. The majority of radiologists used deep filtered x-rays in doses varying between 3,000 and 4,000 roentgens divided in different manners. Harrison⁶⁵ felt that the best results were obtained by using protracted fractional daily doses of 100 roentgens until 4,000 had been administered. At the other extreme Heeren⁶⁸ gave 90 to 120 per cent erythema skin doses at monthly intervals. Usually, potassium iodide and auxiliary surgical measures were employed. The superfluity of potassium iodide is known by some but definitely not accepted by all of the roentgen therapists. Some authors insisted upon adequate drainage and curettage of the lesions, but the majority shared Smith's¹⁰⁰ attitude toward surgery. He wrote, "Radical surgery, including curetting, is probably inadvisable. A study of the cases reported by the authors quoted herein shows that, all other things being equal, those cases which had a minimum of surgical interference recovered more rapidly than did the remainder. Surgical procedures should probably not be resorted to except to provide drainage and to assist in definitely establishing a diagnosis. They should then be limited to a small incision preferably a stab wound."

The efficacy of irradiation therapy in circumscribed superficial actinomycosis is established without a doubt. On the other hand, the results indicate its ineffectiveness in widespread disease.

Vaccines—Specific vaccine therapy of actinomycosis was introduced by Wynn¹⁸⁶ in 1908. The method gained a few adherents in Europe, but has never enjoyed popularity in this country. Colebrook²⁹ of England and the Hungarian dermatologist, Neuber,¹²⁹ are the most energetic proponents of vaccine therapy. The former emphasized the value of concomitant surgery while the latter relied solely upon immunologic methods. A summary of the results with vaccine therapy by several authors is tabulated (see Table V).

The influence of surgical drainage and curettage upon the results reported and attributed to the vaccines is evident and emphasized by Colebrook,²⁹ who

TABLE V RESULTS WITH VACCINE THERAPY OF ACTINOMYCOSIS

AUTHOR	DATE	THERAPY	TYPES OF CASES AND RESULTS												
			CERVICOFACIAL					THORACIC					ABDOMINAL		
			O	C	I	D	N	O	C	I	D	N	O	C	I
Wynn ¹⁸⁶	1908	V, S						1	1						
Colebrook ²⁹	1911	V, S	10	9		1		8			7	1	6	1	5
Dean ³⁴	1917	V, S	1	1											
Schuchardt ¹⁵⁶	1939	V, S	14	12		2									
Neuber ¹²⁹	1940	V	2	2				1	1						
Totals			27	24		3		10	2		7	1	6	1	5

V Vaccine

S Surgery

O Number of cases

C Number of patients cured

I Number of patients improved

D Number of deaths

N No follow-ups

wrote, "The treatment of actinomycosis by vaccines facilitates recovery when efficient surgical drainage of the affected tissue is secured and maintained, when, however, drainage is unsatisfactory the use of appropriate vaccines will not usually suffice to stay the progress of the infection." Colebrook's contribution to the treatment of actinomycosis was really surgical since throughout his report he insisted that in the absence of complete surgical drainage and curettage of the actinomycotic lesions the disease could not be cured. On the other hand, Neuber,¹²⁰ who claimed almost 100 per cent success with the vaccine treatment of actinomycosis, wrote that surgical measures, x-ray irradiation, and iodides are superfluous and unnecessary in curing the disease. He insisted that if the immunologic status of the patient suffering with actinomycosis is carefully evaluated regarding the presence of allergy or anergy and if fresh polyvalent or autovaccines are properly administered in only the allergic patients, cure of the disease is inevitable. The only failures he admits are in anergic patients and in these success may follow the administration of convalescent serum or blood transfusions. Although no statistical data are presented in his recent general review of the subject, the cases illustrated are quite impressive.

Thymol—Thymol was found to be effective in the treatment of a local occupational fungus dermatitis among fruit orchard workers by Myers and Themes¹²⁶ in 1925. They cured a patient with cervicofacial actinomycosis by giving him 15 Gm of thymol twice weekly for two months. Myers¹²⁵ observed that actinomyces were killed in vitro by exposure to 1:1000 concentration of thymol for one minute. Employing adequate surgical drainage with the oral administration and local application of thymol in six cases of cervicofacial actinomycosis, Myers¹²⁴ reported cures in five. A summary of the literature on the results of thymol therapy in the treatment of actinomycosis is appended in Table VI. Etter and Schumacher's⁵² cured thoracic case is quite amazing. The patient had evidence of right upper lobe lung abscesses and coughed up considerable sputum containing sulfur granules. The process healed and x-ray evidence of the disease disappeared after the administration of 2 Gm of thymol daily for seventeen days.

TABLE VI RESULTS WITH THYMOL THERAPY OF ACTINOMYCOSIS

AUTHOR	DATE	THERAPY	TYPES OF CASES AND RESULTS														
			CERVICOFACIAL					THORACIC					ABDOMINAL				
			O	C	I	D	N	O	C	I	D	N	O	C	I	D	N
Myers and Themes ¹²⁶	1925	T	1	1													
Myers ¹²⁴	1937	T, S	6	5			1										
Bancroft and Stanley Brown ⁴	1938	T, S											1		1		
Fang ³¹	1938	T, Co	1	1													
Joyce ³⁶	1938	T	5	3			2										
Etter and Schumacher ⁵²	1939	T															
Clemens ²⁷	1940	T	1	1				1	1								
Totals			14	11			3	1	1				1		1		

T Thymol
S Surgery
O Number of cases
C Number of patients cured

I Number of patients improved
D Number of deaths
N No follow-up
Co Copper SO₄

Sulfonamides—Poulton¹⁴⁰ in 1937 applied sulfonamide therapy to a patient suffering with abdominal actinomycosis who responded badly to irradiation and potassium iodide. The report was part of a general discussion on sulfonamide therapy by the Royal Society of Medicine. He stated that his patient gained weight and left the hospital afebrile, but he did not mention whether or not she was cured. The apparent cure of an abdominal case of actinomycosis by means of sulfanilamide in a 23-year-old man who developed the disease following the removal of a gangrenous appendix was reported in 1938 by Walker.¹⁷⁵ This paper stimulated interest in the sulfonamides in the treatment of actinomycosis. The results obtained with sulfanilamide, sulfapyridine, and sulfadiazine in the treatment of cervicofacial, thoracic, and abdominal actinomycosis have been gratifying as is revealed in the summary of all of the cases reported in the available literature (see Table VII).

Although the sulfonamides were employed empirically in the treatment of actinomycosis by the pioneers of 1938, the rationale of the treatment has been

TABLE VII. RESULTS WITH SULFONAMIDE THERAPY OF ACTINOMYCOSIS

AUTHOR	DATE	THERAPY	TYPES OF CASES AND RESULTS														
			CERVICOFACIAL					THORACIC					ABDOMINAL				
			O	C	I	D	N	O	C	I	D	N	O	C	I	D	N
Poulton ¹⁴⁰	1937	Sn											1			1	
Walker ¹⁷⁵	1938	Sn											1	1			
Miller and Fell ¹²⁰	1939	Sn											1	1			
Muddler and Johnson ¹⁰⁵	1939	Sn	2	2													
Malles	1939																
MacCharles and Kippen ¹⁰⁵	1939	Sn, S	3	3													
Loene ¹²²	1940	Sp, S	1	1													
Gilvie ¹³⁵	1940	Sp, S											1	1			
Forton ¹²³	1940	Sn	1				1	1				1					
Christopher and Karabin ²⁶	1940	Sn, S											1		1		
Dorling and Eckhoff ³⁰	1940	Sn, S, X											5	4			1
Eckhoff ⁴²	1941	Sn, S											2	2			
Woodman ¹⁸⁴	1941	St, S, P											1				1
Jobson et al. ⁸⁸	1941	Sn, S	1	1				1	1				1	1			
Vilkinson ¹⁸¹	1941	Sn, S						1	1								
Fitchell ¹²¹	1942	Sp						1	1								
Myons et al. ¹⁰⁴	1943																
Atwood ²	1942	Sn						1	1								
Rad and Bull ⁹⁷	1943	Sd						1	1								
Hollenbeck and Turnoff ⁸⁰	1943	Sd	1	1													
McCloy ¹⁰⁷	1943	Sp	1	1 (tongue)													
Hillsbury and Wassersug ¹³⁷	1944	Sd, P						1	1								
Benbow et al. ⁹	1944							2	1	1							
Jobson and Cutting ³⁷	1945	Sd, St, Sn	7	6	1			1			1		2		1	1	
Totals			17	15	1		1	10	7	1	1	1	16	10	3	3	
Sn Sulfanilamide.		S	Surgery										C Number of patients cured				
St. Sulfathiazole		X	X-ray										I Number of patients improved				
Sd Sulfadiazine		P	Potassium iodide										D Number of deaths				
Sp, sulfapyridine.		O	Number of cases										N No follow-up				

established experimentally by Cutting and Gebhardt³² who found the growth of two strains of *Actinomyces hominis* was inhibited to some extent by the addition to the media of 10 mg per cent of sulfanilamide and almost completely inhibited by the addition of 50 mg per cent Sulfathiazole and sulfadiazine were much more effective than sulfanilamide in similar concentrations. Experimental actinomycosis could be prevented or cured in rats by the oral administration of sulfanilamide.⁴⁰

Ogilvie,¹³⁵ and Dodson, Holman, and Cutting³⁸ opined that the sulfonamides are beneficial in actinomycosis because of their effect on the concomitant secondary invaders which are inhibited by the drug, thus affording the natural defenses of the body an opportunity to dispose of the actinomyces. In all probability, the effectiveness of the drugs is due to inhibition of both the primary and secondary infectious agents.

Although there have been no definite opinions expressed regarding the simultaneous use of surgical drainage and curettage with the sulfonamides, it is interesting to note that in the majority of patients reported cured, a combination of surgical and drug therapy has been used. Although the number of cases reported is small and the poor results obtained with the drugs have probably not reached the literature, no doubt can exist that the sulfonamides are effective weapons in the treatment of actinomycosis.

Penicillin—With the introduction of penicillin into therapeutics, it was not long before its effectiveness in the treatment of actinomycosis was assayed. In 1941 Florey¹ reported that a strain of *Actinomyces bovis* was as sensitive to the action of penicillin in vitro as the staphylococcus. The next year, Waksman and Woodruff¹⁴ reported that two strains of *A. bovis* were not inhibited by therapeutic concentrations of penicillin in vitro. Fisher⁵⁴ found two strains of *Actinomyces* which were twice as resistant to the action of a crude penicillin extract as the staphylococcus. In 1945, he reported on another strain of *Actinomyces* which was very sensitive to the action of penicillin.⁵⁵

Kenney and associates⁹¹ found that a strain of *Actinomyces* was killed in vitro by 0.01 Oxford units of penicillin per cubic centimeter. They concluded that the *Actinomyces* more closely resembled the true bacteria than the fungi in respect to penicillin sensitivity as the other pathogenic fungi were not inhibited by penicillin in concentrations up to 10.0 Oxford units per cubic centimeter. Selbie and co-workers¹⁵⁷ found that ten strains of *Actinomyces* from human infections were all inhibited by therapeutic levels of penicillin. These organisms fell into two groups, however, one of which was two to four times more resistant to penicillin than the other. Three strains of *Actinomyces* from bovine source were much more resistant to penicillin than the human strains.

Dobson and Cutting³⁷ reported in vitro studies of three strains of *Actinomyces* using sulfadiazine and penicillin. Both drugs effectively inhibited growth. There was no synergistic effect when the drugs were used together. They concluded that sulfadiazine seemed to be more effective than penicillin at levels within the therapeutic range. They noted considerable variation in the sensitivity of the different strains of *Actinomyces* to penicillin.

TABLE X SUMMARY OF CASES

HOSPITAL NO AND AGE (YR.)	DATE	TYPE	SYMPTOMS	THERAPY	RESULT
<i>Cases of Cervicofacial Actinomycosis</i>					
35924*† Male, 43	1925	3	Swelling over left zygoma with extension to involve left side of face from infra orbital region to neck	KI, hot packs, incision of abscesses on 5 occasions	Died, had extension into posterior mediastinum with involvement of esophagus at post mortem
38703*† Male, 65	1926	2	Hard swelling on right side of face extending down on the neck and under the chin, numerous sinuses	X ray irradiation, incision and curettage, KI	Cured
42626*† Male, 34	1927	1	Large indurated swelling of left side of face extending from ear over the maxilla and down into the neck	KI, Lugol's solution, X ray irradiation, incision of abscess	Cured
44891*† Male, 40	1930	1	Hard reddened swelling on right cheek	Excision with endotherm cutting current	Cured
60926*† Female, 29	1931	1	Swelling in left submaxillary region	Excision	Cured
608171*† Female, 13	1932	1	Red indurated mass in right side of face	Partial excision and curettage	Cured
621288† Female, 31	1933	3	8 year history, comatose on admission, numerous sinuses on left side of face, exophthalmus of left eye	Supportive	Died, post mortem showed extension into epidural space, orbit, and liver
622467† Male, 65	1933	2	Swelling of right jaw, draining sinus over right maxilla	KI, X ray irradiation, numerous incisions and curette	Died, post mortem showed actinomycotic meningitis
631495† Male, 7	1934	1	Large swelling on right side of face	Curettage on 2 occasions	Cured
656703 Male, 24	1937	1	Mass in left side of neck	Repeated excision and curettage	Cured
659875 Female, 5	1937	1	Painful swelling at angle of jaw	Curettement	Cured
664208 Male, 55	1937	2	Tender swelling and induration in right neck and jaw, draining sinus	Repeated curettement	Improved, no follow up
708879 Female, 26	1941	3	4 months' history, multiple draining sinuses on right side of face, massive infection, cachexia	Repeated curettage, supportive	Died, post mortem showed actinomycotic meningitis, extension to bones and lung
725491 Male, 18	1942	1	Swelling and pain over right mandible	X ray irradiation, Lugol's, curettage, sulfonamides	Cured
752975 Male, 53	1944	1	Submental swelling	Excision and curettage	Cured

RECENT ADVANCES IN SURGERY

		Swelling below angle of jaw with draining sinus	Radical neck dissection, curet tage	Cured
62058† Male 16	1932	2	<i>Cases of Lingual Actinomycosis</i>	Cured
			Incision and curettement	Cured
			Incision and drainage, abscess on 2 occasions	Cured
611438*† Male, 39	1932	S	<i>Cases of Thoracic Actinomycosis</i>	Died, post mortem showed actino mycosis of lung, bronchopneu mona
504071 Male, 13	1930		X ray irradiation, KI, incision and drainage of abscesses	Died, post mortem showed actino mycosis of lungs, mediastinum, diaphragm and pericardium
50972*† Male, 21	1927		Supportive	Died after 5 year course, no post mortem
55740*† Male, 13	1930		X ray irradiation, excision, drainage and curettement re peatedly, KI resections, in	Died, post mortem showed active mycosis of entire left chest, pulmonary edema of right lung
615300*† Female, 29	1930		Repeated excisions and drainage	Died, post mortem showed actino mycosis of chest wall, multiple lung abscesses, liver abscesses, brain abscess
640072† Female, 14	1935		Repeated excision, incision, cu rettage and rib resection	Improved, no follow up
646743† Male, 15	1935		Sulfamerazine, patient became sensitive to drug, sulfadiazine, 3 week course	Died of cerebrovascular accident while under treatment, actino mycosis had improved
736707 Male, 44	1944		Repeated curettage, excision and rib resection	
746923 Male, 57	1944		<i>Cases of Abdominal Actinomycosis</i>	Died, no post mortem
12506† Male, 17	1917		Cauterization, excision and un roofing of abscess	Died, no post mortem
50181*† Male, 37	1928	3	KI, X ray irradiation, incision of abscess	Died, post mortem showed actino mycosis of ovary, lungs, liver, intrahepatic thrombosis
14025 Female, 40	1928	2	Supportive, drainage of sub diaphragmatic abscess	

*Reported by Randall¹⁴†Reported by Wangenstein¹⁵ m

(Cont'd on following page)

(Fig 2) The pus from the sinuses contained typical sulfur granules. Laboratory findings were hemoglobin, 6 Gm, total plasma proteins, 6.9 Gm. per cent with a reversal of the albumin globulin ratio. X ray examination showed the lumbar vertebrae to be free of disease. An intravenous pyelogram demonstrated normal kidneys and ureters. A barium enema showed displacement of the cecum by an extrinsic mass. A diagnosis of right lower quadrant abdominal actinomycosis (Morton type 3) accompanied by secondary anemia and cachexia was made.

Treatment was directed at the restoration of general health and surgical extirpation of the actinomycotic tissue. Supportive therapy was carried out with vigor (Fig 3). The anemia was treated with ferrous sulfate and liberal transfusions, 3,500 cc of whole blood being administered in the first two weeks of treatment and a total of 10,750 cc throughout the hospital stay. The patient maintained an average intake of 3,500 calories daily. The efficacy of the supportive therapy was checked repeatedly by determinations of the hemoglobin, plasma proteins, and weight.

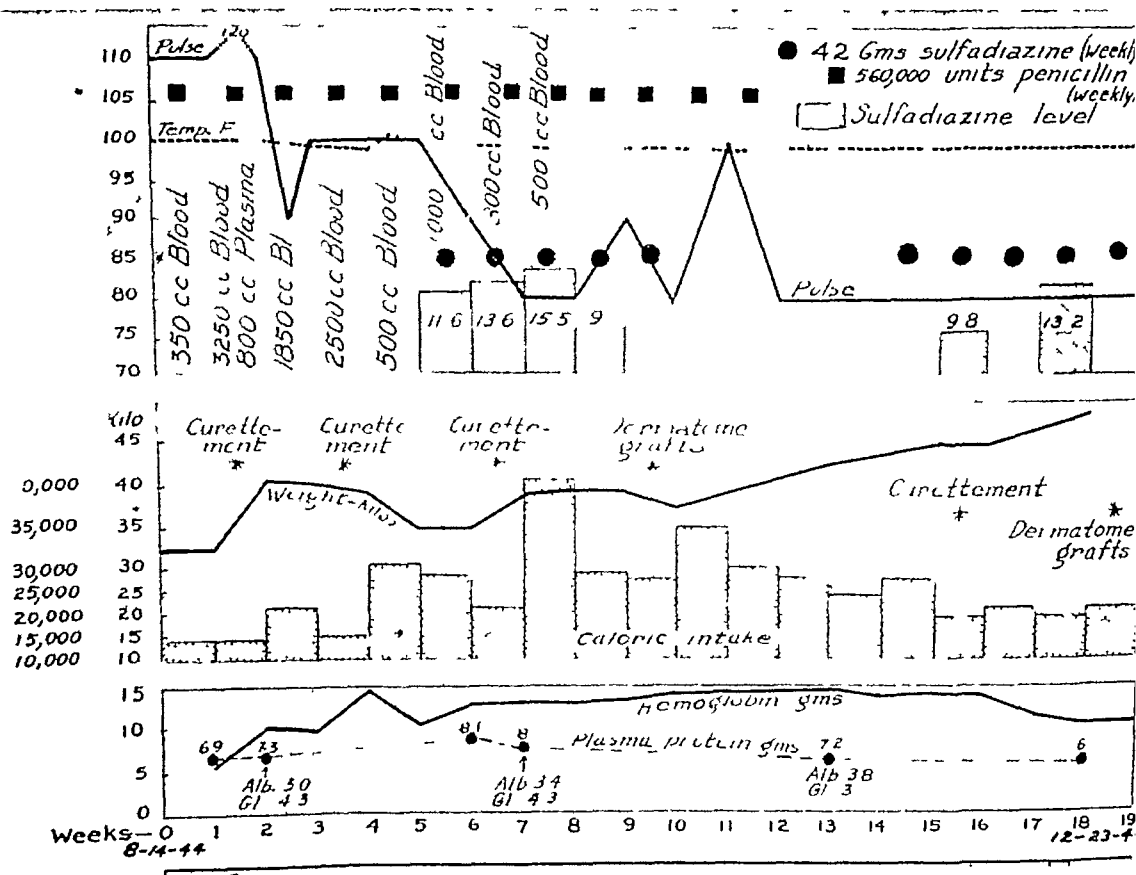


Fig 3—Graph cataloging the treatment of the patient and its reflection upon the body economy

The patient received 10,000 units of penicillin intramuscularly every three hours for twelve weeks. For five weeks during this period the patient was also given sulfadiazine, 1 Gm every four hours, an average level of 12.4 Gm per cent being maintained. For five weeks after leaving the hospital, the patient was given sulfadiazine at home in the same dosage (Fig 3).

The surgical treatment consisted of the removal of the affected tissue in three stages by means of radical excision and curettage (Aug 25, 1944, Sept 7, 1944, Sept 28, 1944).

(Fig 4) Extreme caution was observed while curetting in the region of the cecum to avoid the production of a fecal fistula. The abdominal muscles were detached from the right iliac crest and tissue was removed over the psoas and iliacus muscles posteriorly to the vertebral column, superiorly to the lower pole of the right kidney, and inferiorly into Scarpa's triangle. The wound was irrigated daily with hydrogen peroxide followed by Dakin's solution, and was packed with gauze impregnated with dichloramine T in oil. Granulations progressed favorably. The posterior aspect of the wound was grafted with split thickness grafts on Oct 19, 1944. The remainder was covered in a similar manner on Jan. 2, 1945. The patient has continued

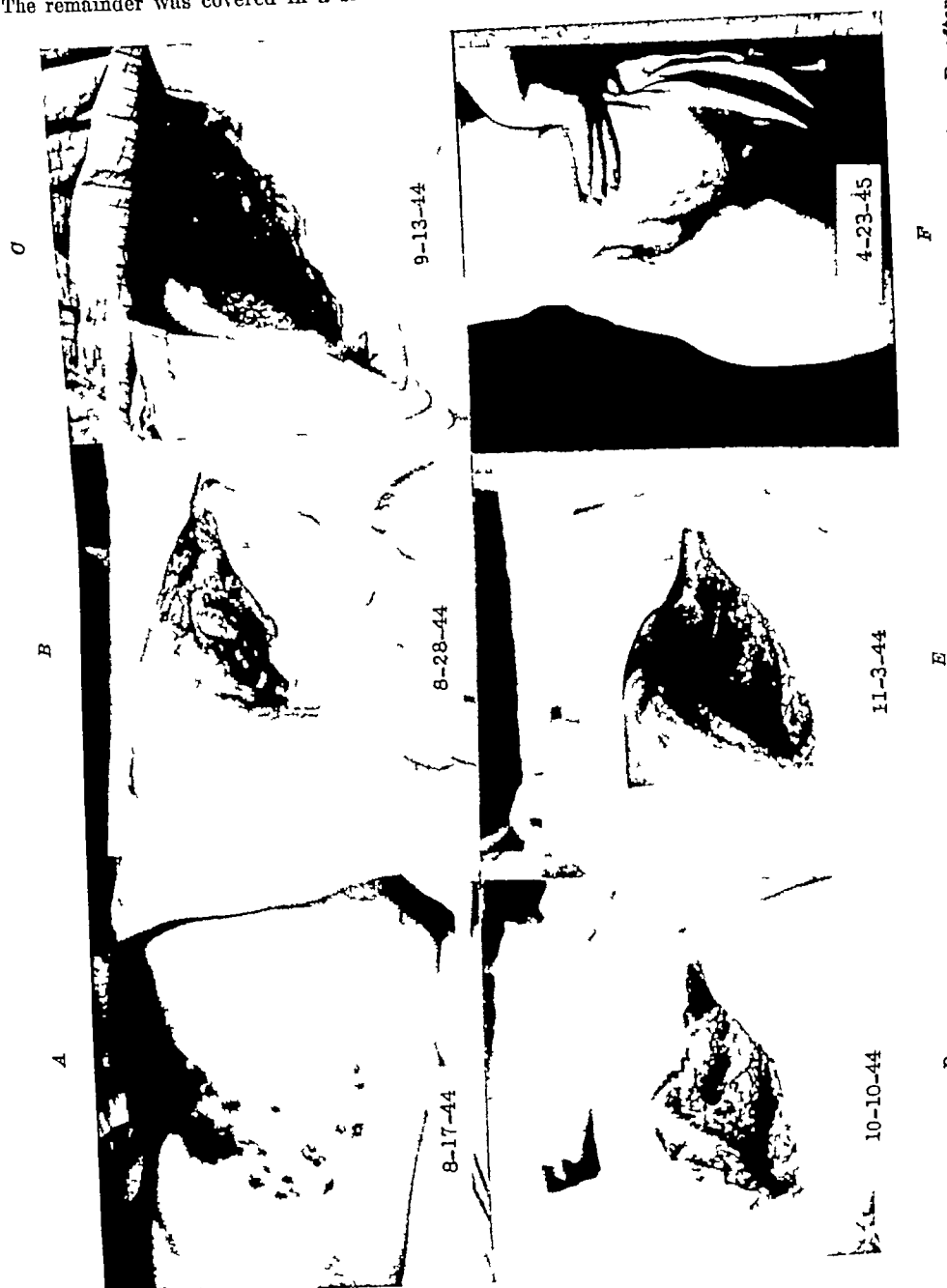


Fig 4—A, Initial appearance of the sinus tracts, B, after the first excision, C, after the second excision, D, after the third excision showing the iliacus and psoas muscles forming the floor of the wound E, prior to skin grafting F, after skin grafting

to gain weight and strength (Fig 5) There has been no evidence of recurrence of the disease A mild scoliosis of the spine has resulted from the detachment of the abdominal muscles from the iliac crest

We believe the apparent cure of this severe case of abdominal actinomycosis was the result of energetic supportive treatment, adjuvant chemotherapy, and radical surgical excision of infected tissue coupled with meticulous wound care The application of dermatome grafts enabled a shortened convalescent period The favorable course of events with this therapeutic regimen in such a severe case of actinomycosis suggests that the prognosis in extensive abdominal actinomycosis is not entirely hopeless

RESULTS

The results in the treatment of cervicofacial actinomycosis show a close correlation between the extent of the lesion at the time treatment was instituted and the eventual prognosis (Table XI) The results in the treatment of thoracic



Fig 5—The appearance of the patient on Jan 15 1945 The dark areas on the right thigh and buttock are healed donor sites of the skin grafts

and abdominal actinomycosis have been poor The success with the last case, however, indicates that the prognosis should not be hopeless in any of these patients

CONCLUSIONS

Success in the treatment of actinomycosis depends to a large extent upon early diagnosis of the condition since circumscribed lesions will respond satisfactorily to any of the recognized forms of treatment Extensive involvement

TABLE XI. RESULTS IN THE TREATMENT OF SIXTEEN CASES OF CERVICOFACIAL ACTINOMYCOSIS CLASSIFIED AS TO TYPE

TYPE	NUMBER	CURED	HEALING	DEAD
1	7	5	2	0
2	6	5	—	1
3	3	—	—	3

irrespective of location presents a serious threat to the life of the patient and a challenge to the ingenuity and perseverance of the physician

Cervicofacial actinomycosis has proved relatively amenable to irradiation, surgery, or chemotherapy. The mortality of this type of infection results from extensions of the infection into vital structures. Repeated excision and curettage as emphasized by Wangenstein¹⁷⁸ appears to be the treatment of choice in extending infections. Adjuvant chemotherapy enhances the possibility of success in the extensive lesions treated by surgery.

Thoracic actinomycosis has been notoriously resistant to treatment prior to the advent of modern chemotherapeutic agents. The sulfonamides and penicillin should bear the burden of treatment in these cases. Surgery should be limited to the drainage of collections of pus and the excision of grossly infected tissue.

Results in the treatment of abdominal actinomycosis have been generally poor. Irradiation therapy of these lesions has been limited by the technical difficulties encountered in applying the treatment to the ramifications of the infected tissue. Aggressive surgical treatment of abdominal actinomycosis has been limited by the poor general condition of the patients. The role of supportive treatment (that is, high caloric intake, liberal transfusions) and adjuvant chemotherapy is to restore and maintain the general condition of the patient at a level tolerating repeated radical excision and curettage of the lesion. Favorable progress of the local lesion depends upon meticulous wound hygiene with the inhibition of secondary infection.

With the conscientious application of generous supportive treatment combined with radical surgery, the prognosis in extensive actinomycosis should continue to improve.

REFERENCES

- 1 Abraham, E. P., and others. Further Observations on Penicillin, *Lancet* 241: 177-188, 1941.
- 2 Atwood, H. S. Actinomycosis of the Lung. Minimal Infection, *Northwest Med* 41: 419-420, 1942.
- 3 Arxhausen, G. Das Frühbild der Kieferaktinomykose, *Deutsche Med. Wchnschr.* 62: 1449-1451, 1936.
- 4 Baneroff, F. W., and Stanley Brown, M. The Treatment of Actinomycosis With Thymol. *Ann. Surg.* 108: 468-471, 1938.
- 5 Bayne Jones, S. Club Formation by *Actinomyces hominis* in Glucose Broth With a Note on *B. actinomycetum comitans*, *J. Bact.* 10: 569-575, 1925.
- 6 Beck, Kiel. Vorstellung von zwei geheilten Bauchaktinomykosefällen, *Zentralbl. f. Chir.* 49: 1775, 1922.
- 7 Bell, E. T. A Textbook of Pathology, ed. 4, Philadelphia, 1941, Lea & Febiger.
- 8 Bell, J. Actinomycosis. Introduction and Recital of Cases, *Montreal M. J.* 34: 81-86, 1905.
- 9 Benbow, E. P., Jr., Smith, D. T., and Grimson, K. S. Sulfonamide Therapy in the Treatment of Actinomycosis. 2 Cases of Aerobic Partially Acid fast Actinomyces, *Am. Rev. Tuberc.* 49: 395-407, 1944.

- 10 Bergey, David H, and others Bergey's Manual of Determinative Bacteriology, ed 5, Baltimore, 1939, Williams and Wilkins Company
- 11 Bevan, A D Actinomycosis, Ann Surg 41 641 654, 1905
- 12 Bevan, A D Treatment of Actinomycosis and Blastomycosis With Copper Salts, J A M A 45 1492 1493, 1905
- 13 Bibby, B G, and Knighton, H T The Actinomyces of the Human Mouth, J Infect Dis 69 148 154, 1941
- 14 Biggart, J H Actinomycosis Graminis, Bull Johns Hopkins Hosp 54 165 173, 1934
- 15 Bisgard, J D Actinomycosis Thoracis Report of Two Arrested Cases, J Thoracic Surg 8 570 575, 1939
- 16 Bollinger, O Ueber eine neue Pilzkrankheit beim Rinde, Centralb f d med Wissensch, Berl 15 481, 1877
- 17 Bostroem Untersuchungen uber die Aktinomykose des Menschen, Beitr z path Anat u z allg Path 9 1240, 1891
- 18 Boyd, W Surgical Pathology, ed 5, Philadelphia, 1943, W B Saunders Company
- 19 Brickner, W M Pelvic Actinomycosis A Study of Five Consecutive Cases Successfully Treated by Operation, Ann Surg 81 303 367, 1925
- 20 Brockman, R St L Actinomycosis of the Right Iliac Fossa, Brit J Surg 10 456-465, 1923
- 21 Brofelt, S Sur l'actinomycose en Finlande, Acta Chir Scandinav 55 167, 1922
- 22 Brogden, J C Actinomycosis of the Gastrointestinal Tract, A Study of Fourteen Cases, J Lab & Clin Med 8 180 189, 1922
- 23 Brunzel, H F Kaguistischer Beitrag zur Behandlung der Aktinomykose mit Rontgenstrahlen, Strahlentherapie 6 253 256, 1915
- 24 Choyce, C C Actinomycosis of the Abdominal Wall, Proc Roy Soc Med 4 79 82, 1910
- 25 Christie, R V, and Garrod, L P A Review of the Work of a Penicillin Therapeutic Research Unit, Brit M J 1 513 514, 1944.
- 26 Christopher, F, and Karabin, J E Abdominal Actinomycosis Recovery Following Surgical Treatment and the Use of Zinc Peroxide and Sulfanilamide, Am J Surg 50 371 372, 1940
- 27 Clemens, H H Actinomycosis, Report of a Case in a Child With Recovery Following Thymol Therapy, J Pediat 16 487 494, 1940
- 28 Colebrook, L The Mycelial and Other Micro Organisms Associated With Human Actinomycosis, Brit J Exper Path 1 197 212, 1920
- 29 Colebrook, L A Report on Twenty Five Cases of Actinomycosis With Special Reference to Vaccine Therapy, Lancet 200 893-899, 1921
- 30 Cope, V Z A Clinical Study of Actinomycosis With Illustrative Cases, Brit J Surg 3 35 81, 1915
- 31 Cope, V Z Actinomycosis, London, 1938, Oxford University Press
- 32 Cutting, W C, and Gebhardt, L P Inhibitory Effects of Sulfonamides on Cultures of Actinomyces hominis, Science 94 568 569, 1941
- 33 Davis, D J The Actinomyces like Granules in Tonsils, J Infect Dis 14 144-158, 1914
- 34 Dean, C W A Case of Actinomycosis Successfully Treated by Vaccine, Brit M J 1 82 83, 1917
- 35 Desjardin, A A Radiotherapy in Actinomycosis, Radiology 11 321 332, 1928
- 36 Dittich, R Die Röntgenstrahlenbehandlung der Gesichts und Halsaktinomykose, Med Klin 16 394 396, 1920
- 37 Dobson, L, and Cutting, W C Penicillin and Sulfonamides in the Therapy of Actinomycosis, J A M A 128 856 863, 1945
- 38 Dobson, L, Holman, E, and Cutting, W Sulfanilamide in the Therapy of Actinomycosis, J A M A 116 272 275, 1941
- 39 Dorling, G C, and Eckhoff, N L Chemotherapy of Abdominal Actinomycosis, Lancet 2 707 709, 1940
- 40 Dosa, A Travaux originaux—Die Heilwirkung des Sulfanids auf die experimentell erzeugte und aktinomykose der ratte, Acta dermat venereol 22 315 319, 1941
- 41 Drake, C H, Sudler, M T, and Canutson, R I A Case of Staphylococcic Actinophytosis (Botryomycosis) in Man, J A M A 123 339 340, 1943
- 42 Eckhoff, N L Actinomycosis, Guy's Hosp Gaz 55 64 67, 1941
- 43 Eiken, T Ueber die Rontgenbehandlung der Aktinomykose, Acta Radiol 6 391 398, 1926
- 44 Ellis, R W B Actinomycosis in Childhood, A Clinical Study and Review, Arch Dis Childhood 10 124, 1935
- 45 Emmons, C W Actinomyces and Actinomycosis, Puerto Rico J Pub Health and Trop Med. 11 63-76, 1935

- 46 Emmons, C W Strains of Actinomyces Bovis Isolated From Tonsils, Puerto Rico
J Pub Health and Trop Med 11 720 727, 1936
- 47 Emmons, C W The Isolation of A Bovis From Tonsillar Granules, Pub Health Rep
53 1967 1975, 1938
- 48 Engelstad, R B Radiumbehandling av ansikts og halsaktinomykose, Norsk Mag f
Laegevidensk 93 161 175, 1932
- 49 Engelstad, R B Radiumbehandling av abdominal aktinomykose, Norsk Mag f
Laegevidensk 94 759 763, 1933
- 50 Erikson, D The Pathogenic Aerobic Organisms of the Actinomyces Group, Medical
Research Council (British), Special Report Series No 203, 1935
- 51 Erikson, D Pathogenic Anaerobic Organisms of the Actinomyces Group, Medical
Research Council (British), Special Report Series No 240, 1940
- 52 Etter, L E, and Schumacher, F L Pulmonary Actinomycosis Recovery After
Thymol Therapy, J A M A 113 1023 1024 1939
- 53 Fang, H C Thymol in the Treatment of Actinomycosis, Chinese M J 54 448 453,
1938
- 54 Fisher, A M The Antibacterial Properties of Crude Penicillin, Bull Johns Hopkins
Hosp 73 343 373, 1943
- 55 Fisher, A M The Therapeutic Value of Penicillin Applied Locally, Bull Johns
Hopkins Hosp 76 134-153, 1945
- 56 Florey, M E, and Florey, H W General and Local Administration of Penicillin,
Lancet 1 387 396, 1943
- 57 Gangolphe, M, and Duplant, F Typhlite and Appendicite Actinomycosique, Rev de
Chir, Par 17 503 518, 1897
- 58 Garrod, L P The Laboratory Control of Penicillin Treatment, Brit Med J 1
528 530, 1944
- 59 Good, L P Actinomycosis of the Thorax, Arch Surg 21 786 800, 1930
- 60 Good, L P Actinomycosis of the Abdomen, Arch Surg 22 307 313, 1931
- 61 Griffith, F Actinobacillosis On the Pathology of Bovine Actinomycosis, J Hyg
15 195 207, 1915
- 62 Grunthal, J Zur Behandlung der Bauchaktinomykose mit Röntgenstrahlen, Fortschr
a d. Geb d Roentgenstrahlen 36 1085 1090, 1927
- 63 Hall, W E B Sulfanilamide in Actinomycosis, J A M A 112 2190, 1939
- 64 Harbitz, F, and Grondahl, N B Actinomycosis in Norway, Am J M Sc 142 386
395, 1911
- 65 Harrison, R S The Radiation Therapy of Actinomycosis, Brit J Radiol 7 98 110,
1934
- 66 Harsha, W M Actinomycosis of the Jaw, Ann Surg 39 459 460, 1904
- 67 Harz Actinomyces bovis, ein neuer Schimmel in dem Gewebe des Rindes, Jahresber
d konigl Central Thierarzneischule zu Munchen, 1877 (cited by Copest)
- 68 Heeren, J Zur Bestrahlungstechnik der Aktinomykose, Röntgenpraxis 1 475-491,
1929
- 69 Hendrickson, G G, and Lehman, E P Cervicofacial Actinomycosis Successfully
Treated by Penicillin Without Surgical Drainage, J A M A 128 438, 1945
- 70 Henkel, K. Die Behandlung der Aktinomykose, Therap d Gegenw 82 171 173,
1941
- 71 Henrici, A T Molds, Yeasts and Actinomycetes, New York, 1930, John Wiley &
Sons, Inc
- 72 Henrici, A T, and Reynolds, G S KI Does Not Influence the Course of Experi-
mental Actinomycosis, Proc Soc Exper Biol & Med 19 255 256, 1922
- 73 Herrell, W E The Clinical Use of Penicillin, J A M A 124 622 627, 1944
- 74 Herrell, W E Penicillin and Other Antibiotic Agents, Philadelphia, 1945, W B
Saunders Company
- 75 Herrell, W E, Nichols, D R, and Heilman, D H Penicillin, J A M A 125 103
111, 1944
- 76 Heyerdahl, S A Einige Falle von Aktinomykose geheilt mit Radium, Zentralbl f
Chir 43 894, 1916
- 77 Heyerdahl, S A Actinomycosis Treated With Radium, J A M A 73 1928 1929,
1919
- 78 Heyerdahl, S A Über die Radium be-handlung der Aktinomykose des Gesichts und
des Halses, Strahlentherapie 25 679 691, 1927
- 79 Haldre, J, and Koskvee, L Beitrag zur Rontgenbehandlung der Aktinomykose,
Rontgenpraxis 12 223 232, 1940
- 80 Hollenbeck, W F, and Turnoff, D Actinomycosis Treated With Sulfadiazine,
J A M A 123 1115 1116, 1943
- 81 Hudson, R V Discussion, Lancet 2 639, 1943

- 82 Israel, J Neue Beobachtungen auf dem Gebiete der Mykosen des Menschen, Arch f path Anat, Berl 74 15 53, 1878
- 83 Israel, J 1885, cited by Cope³¹
- 84 Ittersson and Netter Cited by Henkel²⁰
- 85 Jones, T E, and Brownell, T S Treatment of Actinomycosis With Penicillin, Cleveland Clin Quart 12 32 33, 1945
- 86 Joyce, T M Thymol Therapy in Actinomycosis, Ann Surg 108 910 915, 1938
- 87 Jungling, O Zur Röntgenbehandlung der Aktinomykose, Beitr z klin Chir 118 105 125, 1920
- 88 Kaplan, I I Ein seltener Fall von Aktinomykose Appendicitis, Arch f klin Chir 128 410 416, 1924
- 89 Kay, E B, and Meade, R H Penicillin in the Treatment of Chronic Infections of the Lungs and Bronchi, J A M A 129 200 204, 1945
- 90 Keefer, C S, and others Penicillin in the Treatment of Infections, J A M A 122 1217 1224, 1943
- 91 Keenev, E L, Ajello, L and Lankford, E Studies on Common Pathogenic Fungi and on Actinomyces bovis III. In Vitro Effect of Penicillin, Bull Johns Hopkins Hosp 75 410-416, 1944
- 92 Keijser, S Röntgenbehandlung der Aktinomykose, Strahlentherapie 56 449-455, 1936
- 93 Kirklin, B R, and Hefke, H W The Roentgenologic Aspects of Actinomycosis of the Lungs, Am J Surg 13 1 8, 1931
- 94 Kleesattel, H Zur Frage der Röntgenempfindlichkeit des Strahlenpilzes, Strahlentherapie 17 390 394, 1924
- 95 Kolmer, J A Penicillin Therapy, New York, 1945, D Appleton Century Company, Inc
- 96 Kuhlmann, B Zur Prognose der Röntgentherapie der Lungenaktinomykose, Strahlentherapie 60 476-482, 1937
- 97 Ladd, W E, and Bill, A H Actinomycosis of the Chest With Spread to the Abdomen, New England J Med 229 748 750, 1943
- 98 Levv, B R Röntgenbestrahlung der Aktinomykose, Zentralbl f Chir 40 121 122, 1913
- 99 Lignieres, J, and Spitz, G Actinobacillosis, Semaine méd 9 207 215, 1902
- 100 Lord, F T The Etiology of Actinomycosis The Presence of Actinomycetes in the Contents of Carious Teeth and the Tonsillar Crypts of Patients Without Actinomycosis, J A M A 55 1261 1263, 1910
- 101 Lord, F T A Contribution to the Etiology of Actinomycosis the Experimental Production of Actinomycosis in Guinea Pigs, Boston M & S J 163 82 85, 1910
- 102 Lord, F T, and Trevett, L D The Pathogenesis of Actinomycosis, J Infect Dis 58 115 120, 1936
- 103 Lyons, C Penicillin Therapy of Surgical Infections in the U S Army, J A M A 123 1007 1018, 1943
- 104 Lyons, C, Owen, C R, and Avers, W B Sulfonamide Therapy in Actinomycotic Infections, SURGERY 14 99 104, 1943
- 105 MacCharles, M R, and Kippen, J W Three Cases of Actinomycosis Treated With Sulphanilamide, Canad M A J 41 490 491, 1939
- 106 McCallem, A I Actinomycotic Infection, With Case Reports, Canad M A J 9 411 420, 1919
- 107 McCloy, A Actinomycosis of the Tongue Successfully Treated by Sulphonamides, Brit M J 2 106, 1943
- 108 McCrea, J H, Stevens, R A, and Williams, O O Actinomycotic Infection of the Soft Tissues of the Neck, J Lab & Clin Med 30 509 511, 1945
- 109 McKenty, F L A Study of Cases of Actinomycosis, Am J M Sc 145 835 857, 1913
- 110 McWhirter, R Radiotherapeutic Treatment of Certain Granulomata, Brit J Radiol 11 664-670 1938
- 111 Magnusson, H The Commonest Forms of Actinomycosis in Domestic Animals and Their Etiology, Acta path et microbiol Scandinav 5 170 245, 1928
- 112 Magrou, J E Les grains botryomycotiques, Thesis 267, Paris, 1914 (cited by Cope³¹)
- 113 Nat Res Council Manual of Chemical Mycology, Philadelphia, 1945, W B Saunders Company
- 114 Martin, C J Die Röntgentherapie der Aktinomykose, Strahlentherapie 56 650 659, 1936
- 115 Masson, D M Abdominal Actinomycosis Report of Two Cases With Clinical Cure, Proc Staff Meet, Mayo Clin 11 833 836, 1936
- 116 Mathieson, D R, Harrison, R, Hammond, C, and Henrici, A T Allergic Reactions of Actinomycetes, Am J Hyg 21 405 421, 1935

- 117 Matz, F. Eine seltene Netzhgeschwulst (Aktinomykom), Deutsche Ztschr f Chir 176 217 222, 1922
- 118 Melchior, C. Klinische Erfahrungen uber Kombinierte Jod Rontgentherapie der cervico faciaen Aktinomykose, Berl klin Wchnschr 53 586 587, 1916
- 119 Meloney, F. L. Recent Experiences With Penicillin in the Treatment of Surgical Infections, Bull New York Acad Med 20 517 537, 1944
- 120 Miller, E. M., and Fell, E. H. Sulfanilamide Therapy in Actinomycosis, J A M A 112 731, 1939
- 121 Mitchell, H. S. Sulfapyridine in Actinomycosis, Canad M A J 46 584, 1942
- 122 Moene, I. Behandlung an Aktinomykose, Nord Med 5 335 337, 1940
- 123 Morton, H. S. Actinomycosis, Canad M A J 42 231 236, 1940
- 124 Myers, H. B. Thymol Therapy in Actinomycosis, J A M A 108 1875, 1937
- 125 Myers, H. B. An Unappreciated Fungicidal Action of Certain Volatile Oils, J A M A 89 1834 1837, 1927
- 126 Myers, H. B., and Thienes, C. H. The Fungicidal Activity of Certain Volatile Oils and Stearoptens, J A M A 84 1985 1987, 1927
- 127 Naeslund, C. Experimentelle Studien uber die Aetiologie und Pathogenese der Aktinomykose, Acta path et microbiol Scandinav 8 (Supplement 6), 1 156, 1931
- 128 Naussac, J. The Pathology, Symptomatology and Differential Diagnosis of Pulmonary Actinomycosis, Internat Clin 3 1 18, 1921
- 129 Neuber, E. Spezifische Diagnostik and Therapie der Aktinomykose, Klin Wchnschr 19 736 741, 1940
- 130 New, G. B., and Figi, F. A. Actinomycosis of the Head and Neck, a Report of 107 Cases, Surg, Gynec & Obst 37 617 625, 1923
- 131 Nocard, E. Revue de Med Vet, 1893 (cited by Colebrook²⁰)
- 132 Nordoft, J. Several Cases of Actinomycosis With Reference to Experiments in X ray Treatment, Nord Tidsskr f Terapi Køpenh 12 272 276, 1914
- 133 Northrop, P. M., and Crowley, M. C. The Prophylactic Use of Sulfathiazole in Transient Bacteremia Following the Extraction of Teeth, J Oral Surg 1 19 21, 1943
- 134 Ochsner, A. I. Actinomycosis of the Colon, Surg Clin, Chicago, December, 1920, 1917
- 135 Ogilvie, W. H. Abdominal Actinomycosis Treated With Sulfapyridine, Brit M J 2 254 255, 1940
- 136 Orr, T. G. Actinomycoma of the Third Ventricle, Probably Primary, J A M A 127 757 758, 1945
- 137 Pillsbury, N. R., and Wassersug, J. D. Pulmonary Actinomycosis Treatment With Sulfonamides, New England J Med 230 72 74, 1944
- 138 Ponfick, Die Aktinomykose des Menschen, Berlin, 1882 (cited by Cope³¹)
- 139 Pope, E. L. Actinomycosis An Analysis of 12 Cases, Canad M A J 32 542 545, 1935
- 140 Poulton, E. P. Discussion on the Treatment of Bacterial Diseases With Substances Related to Sulphanilamide, Proc Roy Soc Med 31 149 166, 1938
- 141 Prikul, A. Treatment of Actinomycosis, Deutsche Ztschr f Chir 166 414, 1921, abstracted in J A M A 77 1932
- 142 Ramstad, N. O. Actinomycosis, Journal Lancet 36 732 735, 1916
- 143 Randall, O. S. Actinomycosis, Staff Bull U of Minn Hosp 5 237 250, 1934
- 144 Randall, O. S. The Early Diagnosis and Surgical Treatment of Actinomycosis of the Head and Neck, Am J Surg 57 433-443, 1942
- 145 Renander, A. Le Traitement Radiologique de L'actinomyose Acta radiol 35 1 75, 1936
- 146 Roberts, J. E. H., Tubbs, O. S., and Bates, M. Pleural and Pulmonary Suppuration Treated With Penicillin, Lancet 1 39-45, 1945
- 147 Robinson, R. A. Actinomycosis of the Subcutaneous Tissue of the Forearm Secondary to a Human Bite, J A M A 124 1049 1051, 1944
- 148 Rosebury, T. The Parasitic Actinomycetes and Other Filamentous Micro organisms of the Mouth, Bact Rev 8 189 223, 1944
- 149 Rosebury, T., Epps, L. J., and Clark, A. R. A Study of the Isolation, Cultivation and Pathogenicity of Actinomyces Israelii Recovered From the Human Mouth and From Actinomycosis in Man, J Infect Dis 74 131 149, 1944
- 150 Sanford, A. H. The Distribution of Actinomycosis in the U S, J A M A 81 655 659, 1923
- 151 Sanford, A. H., and Voelker, M. Actinomycosis in the U S, Arch Surg 11 809 841, 1925
- 152 Sardemann, E. Ueber die Behandlung der Aktinomykose mit Rontgenstrahlen, Beitr z klin Chir 90 157 167, 1914
- 153 Sattler, E. Ueber die Bauchaktinomykose, Wien klin Wchnschr 36 714 715, 1923
- 154 Schmidt, H. E. Rontgen Therapie, Berlin, 1920

- 155 Schmitt, S F, and Olson, A M Actinomycosis of the Thorax Report of Two Cases, Proc Staff Meet, Mayo Clinic 16 506 509, 1941
- 156 Schuchardt, K Zur Vaccinetherapie der Aktinomykose, Arch f klin Chir 196 656 661, 1939
- 157 Selbie, F R, Simon, R D, and McIntosh, J Bacteriologic Aspects of Penicillin Therapy, J Path & Bact 57 47 58, 1945
- 158 Shahan, M S, and Davis, C L The Diagnosis of Actinomycosis and Actinobacillosis, Am J Vet Research 3 321 328, 1942
- 159 Slack, J The Source of Infection in Actinomycosis, J Bact 43 193 209, 1942
- 160 Smith, E G Roentgen Therapy of Actinomycosis, Am J Roentgenol 31 823 829, 1934.
- 161 Smith, F L Postoperative Treatment of Abdominal Actinomycosis, S Clin North America 10 171 174, 1930
- 162 Starlinger, F Berichte aus den wissenschaftlichen Vereinen—Aktinomykose der Bauchhöhle, Wien med Wchnschr 88 159, 1938
- 163 Steinkamm, J Die Strahlenbehandlung der Aktinomykose, Strahlentherapie 12 512 516, 1921
- 164 Stocker, H Die Behandlung der Aktinomykose und ihre Resultate, Deutsche Ztschr f Chir 230 169 181, 1931
- 165 Sudler, M T, and Johnson, C B Treatment of Actinomycosis With Sulfanilamide Report of Two Cases, J Kansas M Soc 40 330, 1939
- 166 Sullivan H H, and Goldsworthy, N E A Comparative Study of Anaerobic Strains of Actinomyces From Clinically Normal Mouths and From Actinomycotic Lesions, J Path & Bact 51 253 261, 1940
- 167 v Tempisky, A Resultate der Roentgentherapie bei der Strahlenpilzerkrankung, Beitr z klin Chir 139 207 216, 1927
- 168 Thomassen cited by Colebrook.²⁹
- 169 Topley, W W C, and Wilson, G S The Principles of Bacteriology and Immunity, ed 2, Baltimore, 1938, William Wood & Company
- 170 Von Baracz, R Die Behandlung der Aktinomykose mit Kupfersulfat auf Grund einer 19 Jahrgigen Erfahrung, Zentralb f Chir 49 634 639, 1922
- 171 Wakeley, C P G The Treatment of Actinomycosis by X rays With a Report of 9 Cases, Arch Radiol & Electroth 28 129 135, 1923
- 172 Waksman, S A On the Classification of Actinomycetes, J Bact 39 549 558, 1940
- 173 Waksman, S A, and Henrici, A T The Nomenclature and Classification of the Actinomycetes, J Bact 46 337 341, 1943
- 174 Waksman, S A, and Woodruff, H B Selective Antibiotic Action of Various Substances of Microbial Origin, J Bact 44 373 384, 1942
- 175 Walker, O Sulfanilamide in the Treatment of Actinomycosis, Lancet 1 1219 1220, 1937
- 176 Walker, J M, and Hamilton, J W The Treatment of Actinomycosis With Penicillin, Ann Surg 121 373 384, 1945
- 177 Wangenstein, O H Actinomycosis of the Thorax Report of a Case Successfully Operated Upon, J Thoracic Surg 1 612 636, 1932
- 178 Wangenstein, O H The Role of Surgery in the Treatment of Actinomycosis, Ann Surg 104 752 770, 1936
- 179 Waring, H J Actinomycosis of the Cecum, Vermiform Appendix and Right Ilac Fossa, St Barth Hosp Rep, Lond 41 197 210, 1905
- 180 Weysser, C Heilung einer Frau mit Bauchaktinomykose durch fraktionierte Roentgenbestrahlung, Strahlentherapie 58 234 237, 1937
- 181 Wilkinson, E E Actinomycosis Treated With Sulfanilamide, J Pediat 18 805-810, 1941
- 182 Wolff, M, and Israel, J Ueber Reincultur des Actinomyces und seine Uebertragbarkeit auf Thiere, Virchow's Arch f path Anat [etc], Berl 126 11 59, 1891
- 183 Wollgast, C F The Clinical Use of Penicillin, Report of 115 Cases Treated in Army Hospital, Texas State J Med 40 225 230, 1944
- 184 Woodman, T W Abdominal Actinomycosis, Southwestern Med 25 81 83, 1941
- 185 Wright, J H The Biology of the Micro Organism of Actinomycosis, J Med Research, Boston 13 349-404, 1905
- 186 Wynn, W H A Case of Actinomycosis of the Lung and Liver Successfully Treated With a Vaccine, Brit M J 1 554-557, 1908
- 187 Ziskin, D E, Shoham, J, and Hanford, J M Actinomycosis A Report of 26 Cases, Am J Orthodontics 29 193 201, 1943

Review of Recent Meetings

MEETING OF THE AMERICAN SURGICAL ASSOCIATION

HOT SPRINGS, VA, APRIL 2-5, 1946

J DEWEY BISGARD, M D, OMAHA, NEB

Address of the President, William Darrach, New York—In the treatment of fractures there are five objectives (1) Reduction of secondary trauma to a minimum. Often damage to soft tissues is the major casualty, as a transverse myelitis in fractures of the spine. It is minimized by proper splinting and handling during transportation from site of injury and judicious manipulation in reduction and subsequent treatment. (2) Reduction should be accomplished by the simplest and safest methods necessary to obtain an optimal result. This may be short of the ideal anatomic reduction. (3) Immobilization should be rigid with few exceptions, such as the hanging cast for fractures of the humerus, and it should allow maximum ambulation. (4) Restoration of function should be accomplished as early and rapidly as possible and disuse atrophy minimized by the earliest institution of active motion. (5) Morale and physical and social rehabilitation are important problems in patients with prolonged or permanent major disabilities. For the first time in history, patients with paraplegia from among the wounded of World War II have been made ambulant by skillful psychologic handling and physical training. Compensation insurance relieves many of the injured of personal responsibility and thereby prolongs disability.

In the treatment of compound fractures the early and thorough débridement of the wound is most important. Chemotherapy has a secondary but invaluable place. The question of primary or secondary closure of the wound must be individualized, but in general early secondary closure is safer.

Pharyngoesophageal Diverticulum. Its Management and Complications, Frank H Lahey, Boston—Reported were 202 cases in which operation was done, with one death resulting from leakage from an unobserved perforation of the sac accidentally created during dissection in the first stage of a two stage operation.

The three stages in the development of diverticula were illustrated. Until obstruction develops in the third stage there are either no symptoms or there is merely a sense of pressure or tickling in the throat and the unpleasant sound of air regurgitating from the sac.

Incomplete dissection of the sac results in its inadequate removal and likelihood of recurrence. Wide exposure of the esophagus is necessary to avoid the danger of stricture from too extensive an excision.

A case illustrating the occasional occurrence of carcinoma in the sac was presented.

Diverticula of the Thoracic Esophagus, Robert M Janes, Toronto—Six cases were reported. Four patients were operated upon through a posterior lateral incision through the bed of the seventh rib and all were relieved of symptoms. Special care consisted of preoperative cleansing of the esophagus by lavage and postoperative feeding through a duodenal tube.

The sac was excised and the esophagus sutured in layers with a closed aseptic technique.

Since the mouths of the sacs are wide, there is usually little or no retention. Symptoms consist of periodic episodes of subxiphoid or subscapular pain, a sense of food sticking, and occasionally regurgitation.

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In the discussion of the papers by Lahey and Janes, **S W Harrington**, Rochester, Minn., reported 187 pharyngoesophageal diverticula, most of them operated in a single stage, also four diverticula of the thoracic esophagus. **Robert Dinsmore**, Cleveland, reported a case in which spontaneous perforation had occurred with mediastinal abscess. Preliminary drainage and four subsequent operations were required to eradicate the diverticulum and cure the patient. **Lahey** reported five cases of diverticulum of the thoracic esophagus and described a method in which the sac is dissected free and the fundus inverted and sutured to the mediastinal pleura so that it is proximal to the mouth, discouraging the entrance of food and promoting drainage.

Bronchiogenic Carcinoma, **Gustaf E Lindskog**, New Haven. In 100 consecutive cases of primary lung cancer, the average case age was 55 years. The duration of symptoms in the entire group was 77 months, in the presumably operable (exploration) group, 70 months, in the resected group, 74 months, all of which suggests that duration is of less importance than other factors, such as degree of malignancy and location of the tumor.

Positive tissue diagnosis was made in 73 cases before death by means of bronchoscopy, aspiration, and cells in sputum and pleural fluid. Thirty carcinomas (40 per cent) were presumed to be operable. Of the 30 explorations, 11 proved to be resectable (pneumectomy 9, lobectomy 2). Of the fatal cases, 36 patients received no special treatment and lived an average of 60 months. Of 34 who received deep roentgen therapy, the average duration of life was 74 months, of 11 who had exploratory thoracotomy alone, 76 months, of 7 who died of recurrence or metastasis following operation, 74 months.

In the discussion **Evarts Graham**, St. Louis, reported six patients living and well eight years after total pneumectomy. In a recent series of 246 cases only 18 per cent were resectable. In 80 per cent the diagnosis was established by bronchoscopic examination. **Alton Ochsner**, New Orleans, reported 260 cases, exploration was done in 172 and resection in 28 per cent with 10 per cent mortality. He believes palliative resection is justifiable. **Carl Eggers**, New York, reported a series in which exploration was done in 35 cases and of these pneumectomy was performed in 15 cases and lobectomy in 1. Seven are living and well one to eight years following operation.

Carcinoma of the Mid Thoracic Esophagus Its Treatment by Radical Resection and High Intrathoracic Esophagogastric Anastomosis, **Richard H. Sweet**, Boston.—Reported were thirty-two cases of carcinoma of the middle one third of the esophagus in which alimentary continuity following resection of the tumor along with the esophagus distal to it was reestablished by direct anastomosis to the stomach. The stomach was mobilized by the division of left gastric artery and as much of its mesenteries and other vessels as needed to gain approximation without tension with the proximal severed end of the esophagus. In some of the cases the stomach was anastomosed at a level above the arch of the aorta. Of the thirty-two cases there were eight hospital deaths.

In discussion **Harold Wookey**, Toronto, stated that he had found that transplantation of the esophagus anterior to the aorta facilitated the anastomosis and **Frederick L. Reichert**, San Francisco, stated that additional length of stomach could be gained by mobilizing the duodenum.

Studies on the Use of Gelatin Sponge or Foam as a Hemostatic Agent, **Hilger P. Jenkins** and (by invitation) **Rudolph Janda**, Chicago.—In a series of forty dogs in which the gelatin sponge was used to control bleeding from wounds of the liver or spleen it was found that satisfactory hemostasis was obtained by pressing the gelatin sponge wet with saline into the wound and maintaining gentle pressure for about three minutes. There did not appear to be any substantial increase in the effectiveness of the gelatin sponge in controlling bleeding when the sponge was soaked in thrombin solution. In thirty-five operations on patients the gelatin sponge was effective. There were no difficulties encountered from the standpoint of infection or delay in wound healing. Under favorable conditions the sponge was found to undergo absorption over a period of about one month. In the presence of a conspicuous leucocytic response it was found to undergo liquefaction in a few days to a

week. Gelatin sponge is a valuable absorbable hemostatic agent which compares favorably with soluble cellulose and fibrin foam.

In discussion **W. Jason Mixer**, Boston, commented that at reoperation for neurosurgical lesions he found that gelatin sponges or fibrin foam used for hemostasis at the first operation had left smooth surfaces and a better line of cleavage than muscle and other hemostatic agents.

Studies on the Effects of Adult Tissue Extracts on Wound Healing With a Preliminary Report of Investigations of the Factors Responsible, **William Andrus** and (by invitation) **R. S. Hoffman** and **James A. Dingwall**, New York—Tyrode extract of adult animal tissue has been shown to have an accelerating effect on the growth of fibroblasts and epithelial cells in vitro far beyond that to be expected from the nutrient content of the extract. This effect is neither organ nor species specific and has been confirmed in a controlled series of experimental wounds in animals as well as in refractory wounds in patients.

Tetanus in the Battle for Manila (1945) An Experience Amongst the Civilian Casualties, **Frank Glenn**, New York—Over 500 cases of tetanus occurred in approximately 12,000 civilian casualties from the Battle for Manila, 389 died, a mortality of 80 per cent. When well established, no form of treatment of the disease was effective. In the United States Army there were only eleven cases of tetanus and four of these were fatal. Two of the patients who died had been immunized but had received no booster shots.

In discussion **Edward Churchill**, Boston, stated that the majority of the German soldiers had not been immunized and many died from tetanus. **Warfield M. Firor**, Baltimore, emphasized the ineffectiveness of the known forms of treatment for the advanced and severe cases, and also commented that the cause of death was incompletely understood.

A Systematic Study of Penicillin in the Treatment of Established Surgical Infections, **Frank L. Meleney**, New York—From a study of established surgical infections by the Sub Committee on Infected Wounds and Burns of the National Research Council the following conclusions were drawn. Penicillin is a very effective antibacterial agent, it is effective in two thirds of infections when used either alone or in conjunction with such surgical practices as drainage. It is more effective in acute infection but less effective in mixed infection. Some bacteria are indifferent and some antagonistic to penicillin, such as the colon flora, some of subtilis and saprophytic groups. These groups produce penicillinase. Streptothricin, streptomycin, sulfonamide drugs, and other agents are helpful in ridding the wound of these, the penicillin antagonists. For this reason treatment of infected wounds should be controlled by frequent cultures.

In discussion **John S. Lockwood**, New Haven, stated that there are four known types of penicillin. Penicillin K is ineffective because it is eliminated very rapidly. Commercial products have varied much in effectiveness as the result of the relative proportion of the various types. **Jonathan E. Rhoads**, Philadelphia, stated that peritonitis in dogs responds more effectively to treatment with sulfonamide drugs than penicillin and best with the simultaneous administration of both drugs.

A Quantitative Study of the Anemia Following Burns, **Oliver Cope**, and (by invitation) **Francis D. Moore**, Boston—By means of tagged or radioactive red cells to quantitate the circulating blood, it was demonstrated that severely and deeply burned patients may destroy 100 to 200 cc of red blood cells per day in the first three or four days after burning, and that somewhat later the patients may develop a red cell disappearance which is probably a result of malnutrition and wound infection. In these cases transfused red cells show the same rapid loss. Some factor causing an increase of fragility is a probable explanation. Some marrow depression is an additional contributing factor to the anemia. Early covering of surfaces with skin grafts stops the loss of red cells.

Studies on Water Soluble Vitamins in Burns and Other Severe Trauma, **C. C. Lund**, and (by invitation) **S. M. Levenson**, **R. W. Green**, **J. Lewis**, **C. S. Davidson**, **R. E. Johnson**, and **F. H. L. Taylor**, Boston—Of fifty patients with burns and ten patients with various severe injuries, it was observed that zero levels of vitamin C may be found in the blood.

damage to the colon, rectum, and adjacent structures were reviewed and the respective surgical procedures discussed. Colostomy closure was performed by intraperitoneal anastomosis. Colon resections were performed in one stage. In both procedures an open anastomosis technique was used. Patient's preoperative preparation included sulfaguanidine and thorough daily irrigation of the colon.

No fatalities occurred in this series. Three patients developed fecal fistulas, two of which closed spontaneously. All patients were discharged with satisfactory bowel function.

Congenital Hypertrophic Pyloric Stenosis, Edward J. Donovan, New York—Reported were 507 cases of hypertrophic pyloric stenosis with two deaths. Low mortality was attributed to earlier operations and proper preoperative preparation with glucose and adequate hydration. Reported were two young adults who had had gastroenterostomies in infancy for hypertrophic pyloric stenosis. In both cases the hypertrophic ring at the pylorus was still present and obstructing.

In discussion **William E. Ladd, Boston**, reported 225 patients operated upon in the past three years with no deaths. He warned of the danger of pulmonary edema from overhydration and recommended a high right gridiron incision.

Diverticulitis of the Colon, John Morton, Rochester, N. Y.—The report consisted of 110 cases of diverticulitis with spasm of the bowel only and 85 cases with complications, consisting of perforation with peritonitis and local abscess, cutaneous and vesical fistulas, and sinus formation and obstruction. In the first group the presence of spasm was demonstrated radiographically. Gross bleeding occurred in 20 per cent of the cases. Operative treatment of the patients with complications consisted of proximal colostomy, resection, and drainage of abscesses.

In the discussion **Carl Eggers, New York**, reported 108 cases of which 63 were uncomplicated and 25 had perforated, two into the bladder. Forty-three patients were operated upon and in 12 resections were done. **Harvey B. Stone, Baltimore**, reported two cases illustrative of impending perforation into the bladder. In both cases there was the sudden onset of frequency and dysuria and vesical fistula was prevented by immediate operation. **Vernon C. David, Chicago**, spoke of the occasional complication of pyelophlebitis with liver abscess and warned that carcinoma must be excluded before bleeding can be attributed to diverticulitis. **Damon B. Pfeiffer, Philadelphia** reported the occurrence of massive hemorrhage in diverticulitis.

Late Results in the Treatment of Ulcerative Colitis, Henry W. Cave, New York—The results of operative therapy in 101 cases of ulcerative colitis were reported. In 71 cases ileostomies had been performed, in 63 subtotal colectomies, in 9 partial colectomies, and in 11 the rectum was also removed. Ninety-five per cent of the survivors regained weight and good health in addition to relief from symptoms and endured the ileostomy with good mental outlook. In 3 cases carcinoma developed in inflammatory polyps. Excoriation of the skin about the ileostomy can be prevented by use of fullers' earth and a special bag.

The complications have been intestinal obstruction, prolapse of the ileal stoma, malnutrition, and arthritis.

Richard B. Cattell, Boston, described a method he had used to prevent prolapse, consisting of widely anchoring the mesentery to the parietal peritoneum. **Harvey B. Stone, Baltimore**, referred to a method for preventing prolapse which he had reported. It consists of side to side anastomosis of the proximal and distal loops to form a common pouch just under the peritoneum. **James D. Rives, New Orleans**, spoke of a group of patients who are not benefited by ileostomy or colectomy. All are women and in all of them the bowel is normal in appearance.

Palliative Gastrectomy in Selected Cases of Gastric Ulcer, Ralph Colp and (by invitation) Leonard Druckerman, New York—Eight cases were reported with chronic gastric ulcers high on the lesser curvature in which subtotal gastrectomy leaving the ulcer in situ had been done. There was one death. All patients were rendered achlorhydric and in all the ulcers promptly healed as indicated radiographically and by absence of symptoms.

In discussion **Richard H. Sweet**, Boston, expressed a preference for resection of the proximal portion of the stomach including the ulcer through the diaphragm by way of the intrathoracic approach. This precludes the hazard of leaving a misjudged carcinomatous ulcer.

Radical Surgery in Cases of Calcification of the Pancreas, Allen O. Whipple, New York—The lesion of calcification of the pancreas is relatively rare. The cause of these calcific changes is not clear although previous attacks of acute pancreatitis or acute cholecystitis have been noteworthy in some cases.

The pathology in these patients varies considerably both as to the location and extent of the calcific changes, and the relation of these changes to the symptomatology. The amount of calcification around the ducts and the number of calculi in the ducts largely determines the number and size of associated cysts in these lesions. Whether previously developed areas of destroyed or damaged pancreatic tissue results in calcification is not clear, in some this seems to be the case. The extent of this calcific change does not necessarily determine the severity of symptoms. But in the patients operated upon pain has been the most marked and compelling symptom. This pain has been in the epigastrium, severe, fairly constant, radiating into the lower dorsal and upper lumbar region, made worse after eating, frequently so severe as to require opiates.

Physical signs are few or absent. There may be persistent tenderness along the pancreas. The diagnosis is based largely on the severe epigastric pain with the finding of patchy or nodular areas of calcification or calculi in a part or all the pancreas in the x-ray views of the upper abdomen. The removal of the part of the pancreas involved in the calcification, and in two instances a complete pancreatectomy, has resulted in relief of pain. If the head of the pancreas or all the pancreas has been removed, the duodenum has been excised, and in the cases of complete pancreatectomy, the spleen has also been removed. In these procedures a choledochojejunostomy and a gastrojejunostomy, as in the radical operation for carcinoma of the head of the pancreas, have been done.

A collected series of ten cases from several clinics was reported. After total pancreatectomy a surprisingly small quantity of insulin is required to maintain sugar metabolism.

In discussion **Alexander Brunschwig**, Chicago, stated that extensive calcification of the pancreas may exist with little or no symptoms.

Results From Using Vitallium Tubes in Biliary Surgery, Herman E. Pearse, Rochester, N. Y.—A follow up study of 216 cases in which a vitallium tube was used to repair the common duct was reported. The majority of these data were obtained from correspondence with members of the American Surgical Association or their associates.

In 106 cases the vitallium tube was used to reconstruct the common bile duct. Of these, there were good results in 85 cases (80.1 per cent) and poor results in 12 cases (11.3 per cent) because of plugging of the tube. By analysis the material is largely bile pigment. If the tube plugs two or three years after its insertion, the duct reconstitutes to normal caliber. The tube may then be removed and the duct closed with good result.

In 79 cases the vitallium tube was used to anastomose the hepatic duct to the duodenum. There were good results in 46 cases (58.2 per cent) and poor results in 27 cases (34.1 per cent) because the tube was passed into the bowel. There were 18 cases in which the vitallium tube was used in anastomosing the hepatic duct to the jejunum. Of these, there were satisfactory results in 15 cases (83.3 per cent).

Pancreatitis as a Cause of Complete Obstruction of the Common Bile Duct, J. Dewey Bisgard, Omaha—Reported were two cases of relatively painless jaundice with complete obstruction of the common bile duct in which it seemed probable that the jaundice resulted from temporary compression of the duct by swelling of the surrounding pancreatic tissue. No other etiology was demonstrated at operation and complete recovery followed surface drainage of the proximal common bile duct. Narrowing of the intrapancreatic portion of the duct was demonstrated by postoperative cholangiograms and subsequent progressive dilation was demonstrated in serial cholangiograms made through the indwelling T tube.

In discussion **I. S. Ravdin**, Philadelphia, stated that failure of filling of the distal portion of the common bile duct was indicative of spasm of the duct but he failed to explain how spasm can occur in the duct which has no muscle

Unusual Surgical Lesions of the Umbilicus, Carrington Williams, Richmond, Va.—The conditions reported were the result of abnormal embryonic development either from persistence of an embryonic structure which should have disappeared or from faulty cleavage in the midline. The cases included cyst of the urachus, cyst of the vitelline duct, abscess of the urachus, hernia into the umbilical cord, amniotic hernia, eventration of the omentum, and primary carcinoma

Treatment of Bedsores by Total Excision and Primary Plastic Closure, James O White, Captain, and (by invitation) **William Hamm**, Captain, MC, USNR—With the protection of penicillin, decubitus ulcers can be resected and closed by primary suture. This permits rapid closure with full thickness skin and early rehabilitation of patients with spinal paraplegia

Adequate preliminary treatment is essential to combat anemia, hypoproteinemia, and avitaminosis. Bladder paralysis is treated by tidal irrigation, chemotherapy and surgical measures are used to clear up sepsis in the urinary tract and the tissues surrounding the decubitus

The ulcer is then débrided and plastic skin flaps swung in for primary closure. A compression dressing is applied and penicillin given intramuscularly during the healing period.

Experience proved that clean healing was the rule. Hematomas or undue tension resulted in small defects which heal cleanly but more slowly. Within fourteen days, many of these lesions were firmly healed with well padded movable skin covering the former defect

Primary Closure of Decubitus Ulcers, John H. Gibbons, Jr., Philadelphia, and (by invitation) **Leslie W. Freeman**, Captain, MC, A US—World War II has left many hundreds of patients with paraplegia and the problem of treating their decubitus ulcers. Reported were sixty decubitus ulcers treated by complete excision of the ulcer, its margin, its base, and all pockets, followed by wide undermining, rotation of full thickness skin flaps with attached subcutaneous tissue, and primary closure. Adequate nutrition is essential before operation. Preoperative levels of blood vitamin C, plasma protein, and hemoglobin were reported

Important technical points are avoiding tension, using cotton sutures, and avoiding contamination of the wound during excision of the ulcer

The results were: healed primarily, 37; healed in four weeks, 4; partial healing, improved, 5; complete failures, 3, too recent for comment, 11

The conclusions were that spontaneous healing and skin grafting do not result in full thickness skin and subcutaneous tissue over bony prominences. The treatment of choice in decubitus ulcers is radical excision and primary closure by rotation of the adjacent full thickness skin flaps

In discussion of the last two papers **Charles C. Lund**, Boston, stressed the importance of nutrition in these patients and outlined a diet containing skimmed milk, amigen, liver extract, and sugar containing 2,500 calories and 320 Gm protein, fortified with vitamins. **Robert H. Ivy**, Philadelphia, expressed a preference for the technique described by **White** because in his technique the line of suture is not placed over the ulcer. **Robert H. Kennedy**, New York, remarked that a prompt dramatic improvement in appetite and nutrition follows closure. **James White**, Boston, suggested that the use of pyruvic acid for rapid removal of necrotic tissue would make it possible to close the ulcers earlier. **Gibbons** believes that it is not necessary to await closure of the ulcer until the wound is clean and the undermining has ceased

The Treatment of Acute Renal Failure by Peritoneal Irrigation, Jacob Fine, Boston—Renal damage following extensive muscle crush injury, incompatible blood transfusion,

sulfonamide hypersensitivity, and in other circumstances is not necessarily irreversible. Uremia can be treated successfully and death may be prevented during the period necessary for recovery of renal function, if the peritoneal cavity is utilized properly as a dialyzing membrane.

Through a tube of entrance leading into the upper part of the abdominal cavity and a tube of exit leading out of the pelvis, 20 L. or more of physiologic solution are circulated daily. If edema is present gelatine is added to the irrigating solution. Meticulous care is used to maintain asepsis and penicillin and sulfonamide drugs are used constantly to prevent peritonitis. Difficulty has been encountered in maintaining free circulation of the fluid through the peritoneal cavity.

Of five patients with renal shutdown in whom this procedure was used, one recovered. All showed a prompt drop of the blood nonprotein nitrogen to normal and maintenance of this normal level. In discussion **Arthur B. McGraw**, Detroit, reported a case in which this same procedure had been used with temporary benefit. **Alton Ochsner**, New Orleans, reported that Bliss had carried out the same procedure in nephrectomized animals and reported two patients who had been cured by lavage of the stomach with 20 L. of saline solution daily. **Jonathan E. Rhoads**, Philadelphia, presented a method by which the blood after heparinizing the patient is circulated outside of the body through a circuit from artery to vein consisting of plastic tube immersed in a bath of a physiologic solution, the tube acting as a dialyzing membrane. **Ralph Colp**, New York, directed attention to a report from Holland of a device utilizing the same principle and similar to that described by Rhoads.

Early Ambulation in Abdominal Surgery, **John O. Burch**, and (by invitation) **H. C. Fisher**, Nashville, Tenn.—Early ambulation after abdominal operations affords a marked reduction in postoperative pulmonary and thromboembolic complications. In addition, there is a quicker return of normal bodily function as well as bladder and bowel functions. Early rising increases vital capacity, restores normal vascular tone and blood volume, and probably hastens wound healing.

In discussion **Bradley L. Coley**, New York, stated that among the patients treated in the hospitals in the Eighth Service Command where early ambulation was practiced there was 150 with phlebitis and 54 with pulmonary emboli.

Resection of Abdominal Carcinomas Involving the Liver and Spleen Secondarily, **Alexander Brunschwig** and (by invitation) **Douglas R. Morton**, Chicago.—Ten cases in which the primary neoplasms of abdominal viscera together with one or more hepatic metastases were excised were reported. Two patients were living and well four years after operation, others living shorter periods received palliation. It is probable that an individual develops some immunity to cancer.

In the discussion **Dallas B. Phemister**, Chicago, stated that the fact that these extensive operations were well tolerated when the circulation was maintained with the transfusion of adequate blood and fluid refuted the neurogenic theory of shock.

Studies on Nutrition—The Effect of Preoperative Force Feeding on Surgical Patients, **C. Everett Koop**, introduced by **Jonathan E. Rhoads**, Philadelphia.—A group of twenty-six patients undergoing major abdominal or intracranial operations were studied for the effect of preoperative hyperalimentation on the postoperative course. Eleven of these patients were force fed 0.9 Gm. of nitrogen per kilogram per day (about three times the normal postoperative requirement) for five preoperative days. The remaining fifteen patients served as controls. The response of the patients in the preoperative force fed group to the tilt table procedure suggested that their circulatory changes were somewhat less severe than those in the control group. Ballistocardiographic studies were made on all patients at comparable intervals pre and postoperatively. These studies gave inconclusive results. The objective benefits of the program of preoperative force feeding were most noticeable in the group of neurosurgical patients undergoing craniotomy or craniectomy.

Arteriovenous Aneurysm of the Vertebral Vessels Report of Eight Cases, Daniel C Elkin, Colonel and (by invitation) M. H. Harris, Major, M C, A U S—Arteriovenous aneurysms of the extracranial portion of the vertebral vessels are rare. In a series of 450 cases of aneurysm and arteriovenous fistulas in an Army General Hospital, ten patients with this unusual lesion were encountered and all cured by operation. In cases previously reported there was a mortality of 50 per cent. These aneurysms are approached through an incision traversing the sternocleidomastoid muscle, exposing the transverse processes of the vertebrae at the level of the aneurysm. The vessels above and below are exposed by removing the overlying bone, and ligated proximally and distally.

Rudolph Matas, New Orleans, reported his experience with one case in which he opened the artery at the site of the aneurysm and plugged it with a small sea sponge. This controlled bleeding. The sea sponge absorbed and obliterated the aneurysm. Wilder Penfield, Montreal, Canada, reported a case in which he ligated the artery at the level of the fifth and sixth cervical vertebrae with no relief, therefore he ligated the proximal end through a cerebellar approach.

Kymographic Observations of the Heart in the Presence of an Arteriovenous Fistula and Their Interpretation, Emile Holman, San Francisco—Kymographic studies with the fistula open and closed reveal a definite additional distention of an already dilated left ventricle and aorta on closing femoral and popliteal fistulas. This is the result of an abnormally increased blood volume in compensation for leakage through the fistula. The amount of increased blood volume and the corresponding changes in the heart are dependent upon the size of the fistula and this in turn is determined to some extent by the scar surrounding the fistula. After permanent surgical closure of the fistula, the increased blood volume shrinks to a normal level.

The Surgical Treatment of Congenital Pulmonary Stenosis, Alfred Blalock, and (by invitation) Helen Taussig, Baltimore—Reported were ninety one patients, between ages 5 months and 21 years, operated upon with a mortality of 23 per cent. All but one of the survivors showed improvement with disappearance of cyanosis and an increase in activity without dyspnea. Several resumed fairly normal activity. For the anastomosis the innominate, subclavian, and carotid arteries have been used. The subclavian artery is preferred because of hemoconcentration. Transfusions are seldom necessary. If not much blood is lost at operation some is withdrawn afterward. Several patients developed hemiplegia but the majority of these cleared.

Allen Whipple, New York, commended the authors for opening a new important field in surgery. Claude Beck, Columbus, Ohio, stated that funds were available for research in cardiovascular disease. Emile Holman, San Francisco, reported two cases. In one the common carotid artery was mobilized in the neck and brought down into the chest to anastomose to the pulmonary artery. A hemiplegia developed in five days.

Arterial Repair in the Treatment of Aneurysms and Arteriovenous Fistulas With a Report of Twenty Successful Restorations, Norman E. Freeman, Philadelphia—In case that a large defect in the arterial wall is present, lateral suture may restrict the lumen of the vessel. With transvenous repair, a possible second perforation of the artery may be overlooked. In order to overcome these objections the following technique has been developed. After control of the component vessels, the artery is cut from the vein. The opening into the latter is closed by a running suture. The damaged portion of the arterial wall is then excised and the defect closed transversely.

Arterial repairs, the greater number by transverse suture, were performed in twenty four cases of aneurysms and arteriovenous fistulas. Success of the repair was demonstrable in twenty of the twenty four cases.

The following arteries were successfully repaired: Abdominal aorta, 1, common carotid, 2, subclavian, 2, brachial, 2, superficial femoral, 6, popliteal, 7.

Daniel C. Elkin, Emory University, Ga., stated that in 800 cases with quadruple ligation, gangrene of the extremities developed in only two cases. Twelve patients subse-

quently had intermittent claudication. In eighteen cases in which restorations were performed, there was one failure and two cases with subsequent claudication. **Rudolph Matas**, New Orleans, said that an effort should always be made to preserve the carotid, popliteal, and femoral arteries above the profunda in continuity. **Isaac Bigger**, Richmond, Va., pointed out that a diminution in circulation develops later.

Surgical Treatment of Angina Pectoris, Experiences With Ligation of the Great Cardiac Vein and Pericoronary Neurectomy, **Mercier Fauteux**, introduced by **Elliott C. Cutler**, Boston.—Two essential objectives must be attained for alleviation of symptoms and improvement of cardiac circulation: (1) abolition of reflexes which produce coronary spasm, ventricular fibrillation, and anginal pain, (2) acceleration of the natural mechanisms which cause establishment of compensatory circulation and development of an efficient collateral circulation.

Experimental studies demonstrated that the first objective can be obtained by pericoronary neurectomy, and the second by ligation of the great cardiac vein. Both procedures must be accomplished to give maximum benefit to the patient. Fifteen patients operated upon during the past six years were reported upon.

neath the posterior longitudinal ligament, but on page 91 the herniation is spoken of as having ruptured completely through the posterior longitudinal ligament and lying free in the spinal canal

The statement that "the correct diagnosis is now made clinically in about 80 per cent of patients having herniation of the nucleus pulposus" is certainly open to question, since no proof is offered to support this optimistic statement

The importance of functional disease in the differential diagnosis of low back and sciatic pain would seem to warrant more than a comment that "the *experienced observer* will not be deceived in the identification of the symptoms and signs of a true sciatic pain" This misleading statement may lead to many unnecessary operations on patients with symptoms and signs simulating disc lesions, but the etiology of which is functional

Although inadequacies are present in the book, they are few, and it is an excellent summary of the problem The book deserves careful consideration by all those interested in the herniated intervertebral disc

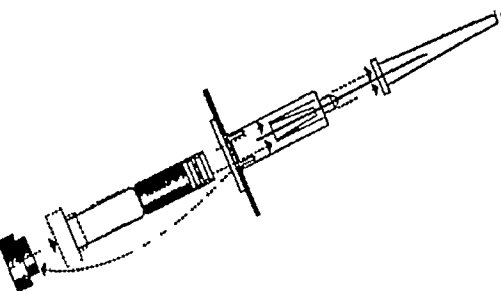
Bone Grafting in the Treatment of Fractures. By J R Armstrong, M D, M Ch, F R C S
Baltimore, 1945, Williams & Wilkins Company \$7

This monograph on bone grafting in the treatment of fractures covers nearly all types of nonunion The techniques, on a whole, are good, preoperative and postoperative care is rightly stressed and the proper selection of cases is discussed General principles of bone grafting are concisely presented Most modern grafting techniques, with some modifications, are described One type not described which has found a useful place in this country is the combination of a plate with a graft, either of cortical or cancellous bone In some illustrations, fixation seems inadequate as only one screw is used in each end of a graft

Exception may be taken to the time during which a tourniquet is allowed to remain on an extremity On the arm, the time allowance stated is up to two and one half hours and on the leg, up to three hours Tourniquet palsies may result if tourniquets are in place for this length of time The text also advocates that the tourniquet remain on until after the wound has been closed and a cast or dressing applied Preferably, one should release the tourniquet, catch bleeders, and then close the wound Hematomas and subsequent infections can result if bleeding points are not secured

Aside from the aforementioned objections, the book may be highly recommended The techniques and the illustrations are good

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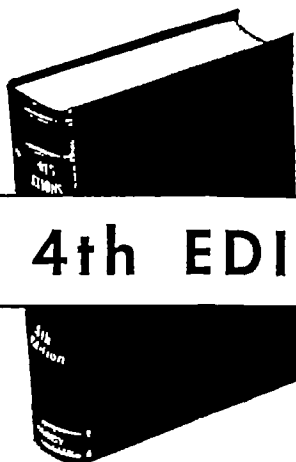
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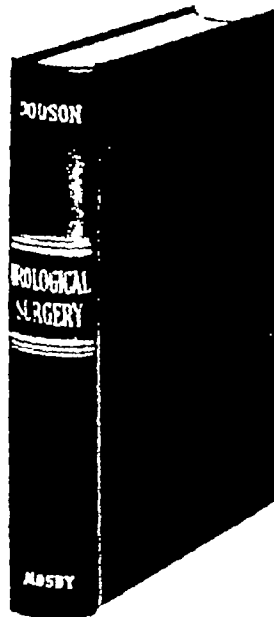
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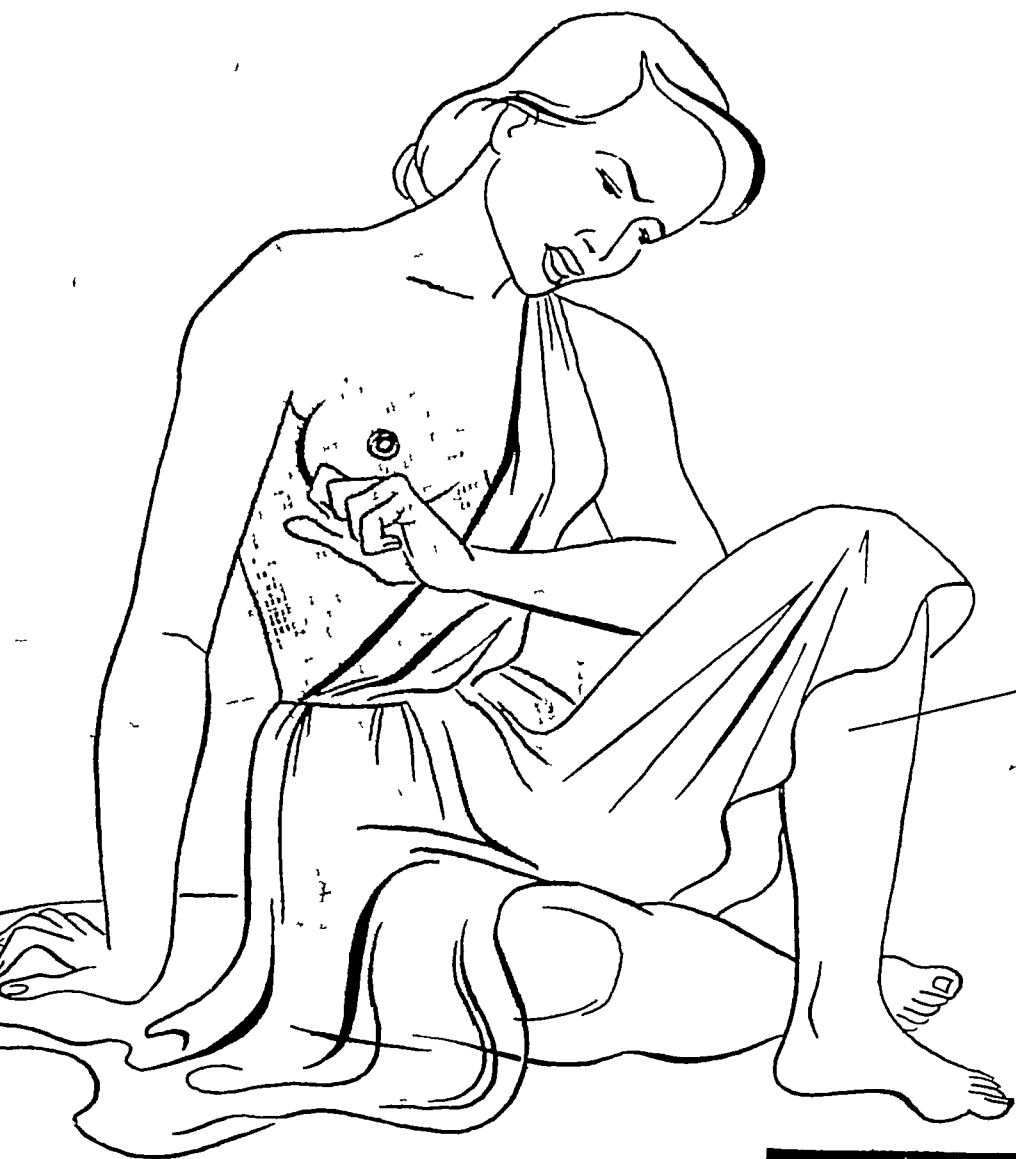
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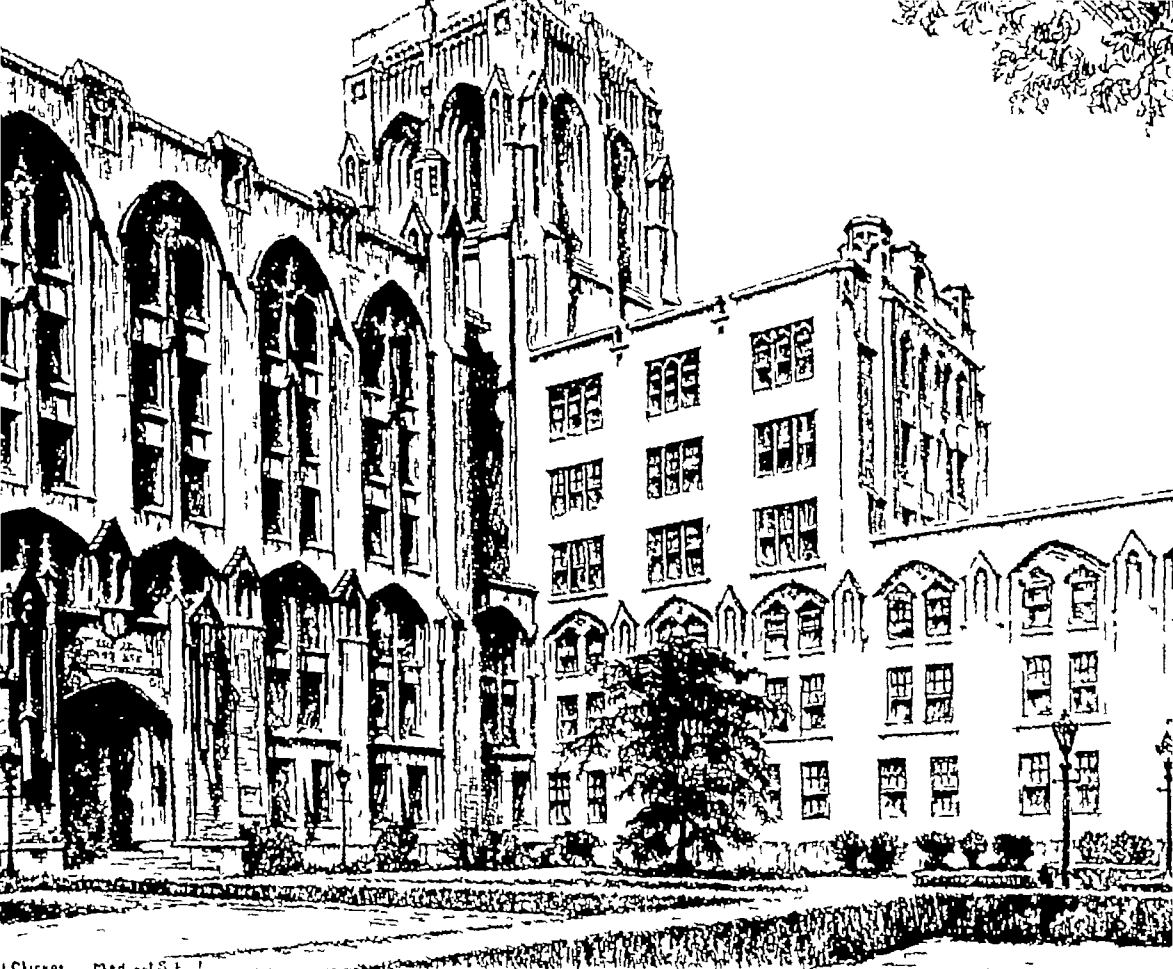
Goodrich, L. and Gilson, A. The Pharmacological Basis of Therapeutics, New York, The Macmillan Company 1941 p.186.
Betheman, E. C., and Mulholland J. H. Arch. Surg. 44:404 1943.

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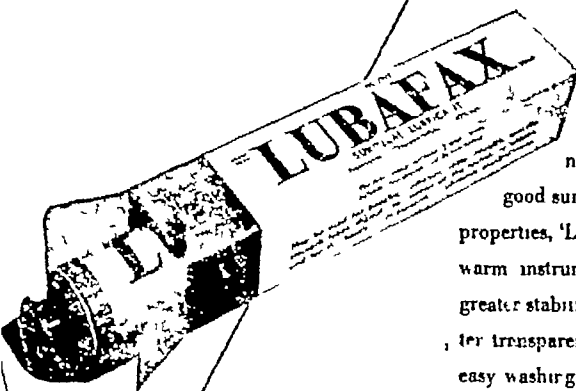


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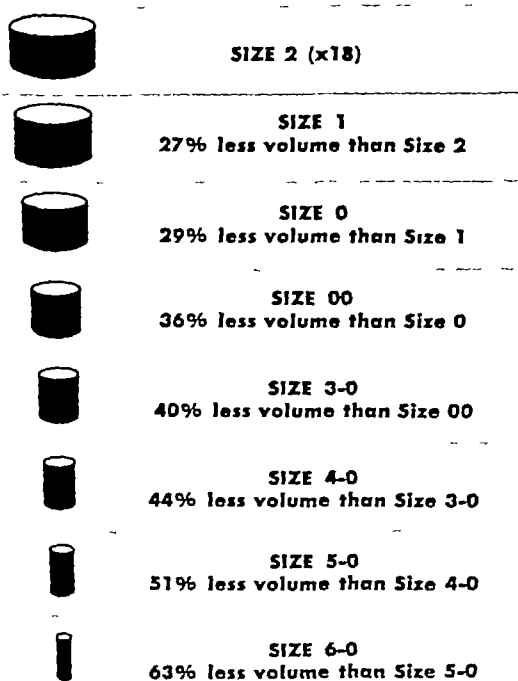
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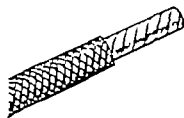
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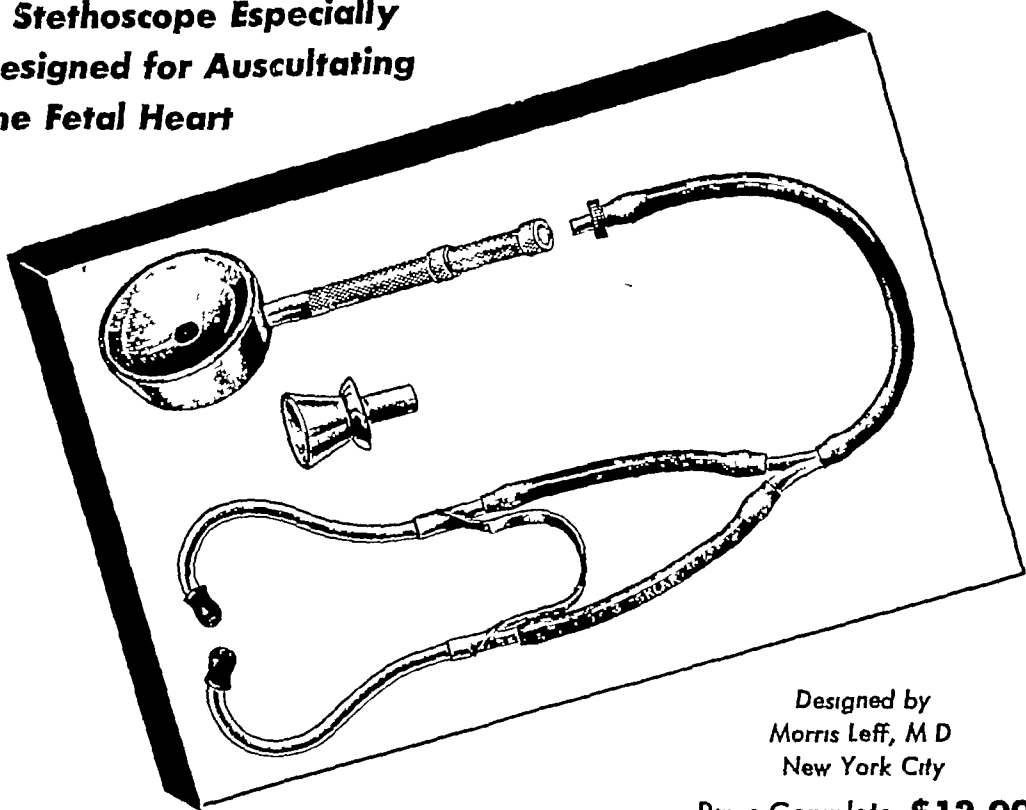
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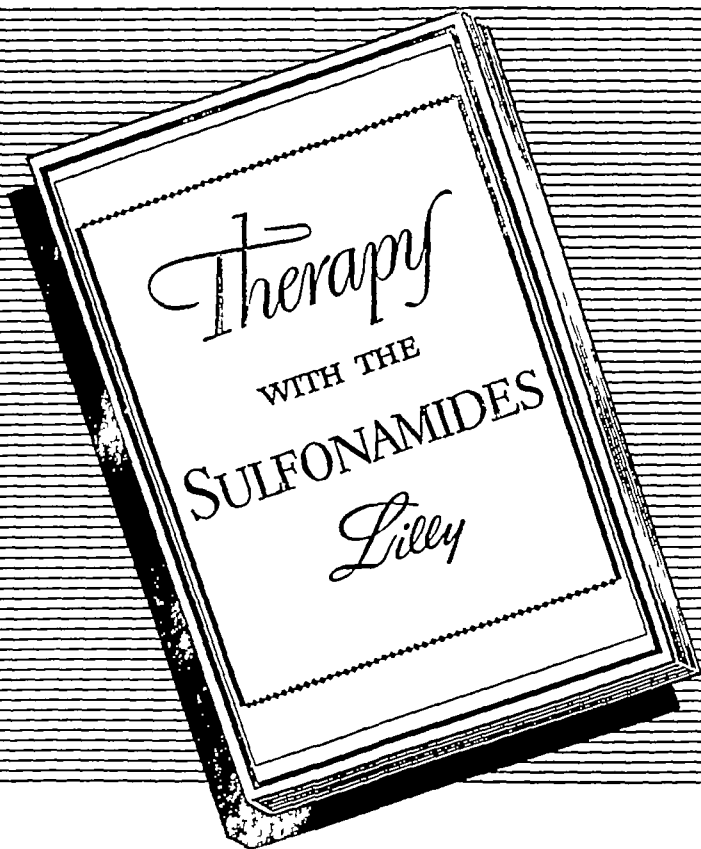
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SURGERY

VOL 20

OCTOBER, 1946

No. 4

Original Communications

THE USE OF STREPTOMYCIN IN EXPERIMENTAL PERITONITIS

JOHN J MURPHY, M D, ROBERT G RAVDIN, M D, AND

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*(From the Harrison Department of Surgical Research, Schools of Medicine,
University of Pennsylvania)*

THE use of chemotherapeutic agents in the treatment of peritonitis and prophylactically in those conditions in which, in the past, the incidence of peritonitis has been high was attended by substantial reductions in the mortality rates. The use of sulfanilamide in acute appendicitis gave very favorable results in England² and also in our own clinic^{6, 7}. The local use of sulfonamides as an adjunct to surgery of the large bowel has also been attended by a substantial reduction in mortality^{6, 8}. Experimental evidence of the value of sulfonamides in peritonitis goes back to the original experiments of Domagk,³ who demonstrated the value of these drugs in the treatment of peritoneal infections in mice. The first attempt to reproduce the mixed type of peritoneal infection commonly seen in human peritonitis and to test the effect of sulfonamides on it was that of Bower and his associates¹. These investigators found a very substantial reduction in mortality following the administration of prontosil. More recently the value of penicillin in experimental peritonitis produced by a modification of Bower's method has been tested by Fauley and his associates⁴. Again the results were gratifying.

The development of streptomycin* by Schatz and his associates¹¹, and by members of the staff of the Merck Institute has provided an antibiotic which is relatively nontoxic and which, following parenteral administration, becomes widely distributed in body fluids^{9, 15}. It is polyvalent to a much greater degree than penicillin or the sulfonamides. Its effectiveness against many strains of organisms of the colon group differentiates it strikingly from penicillin^{10, 11}. It was thought that this property might make it an unusually valuable agent in

The work described in this paper was done under a contract recommended by the Committee on Medical Research between the Office of Scientific Research and Development and the University of Pennsylvania.

Received for publication, Dec. 15 1945

*The Streptomycin was supplied by Merck & Company Inc. New York, N. Y.

the treatment of acute diffuse peritonitis due to mixed infections with both gram-positive and gram-negative bacteria

Since the organisms of the colon group are the types most frequently found in the common forms of human peritonitis, it seemed logical to substitute streptomycin for sulfonamides and penicillin. However, before giving up the use of sulfonamides and penicillin, which are drugs of proved if of limited value, it seemed important to test it in experimental peritonitis in dogs.

The experiments to be described in this paper indicate that it is a valuable agent in this condition, although in the dosage used it falls far short of complete effectiveness.

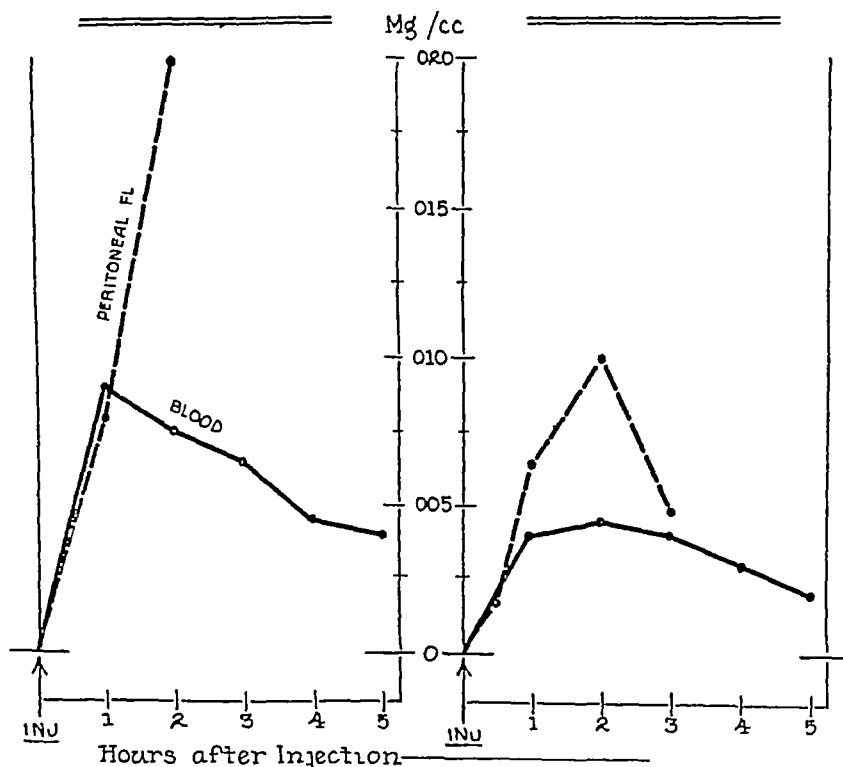


Fig 1—Concentrations of streptomycin in blood and peritoneal fluid following single intramuscular injection of streptomycin HCl 100 mg and single intraperitoneal injection of 200 c.c. physiologic saline solution; single intramuscular injection of streptomycin HCl 50 mg and single intraperitoneal injection of 200 c.c. physiologic saline solution.

In order to determine whether or not streptomycin would pass into the peritoneal cavity of normal dogs, samples of blood and peritoneal fluid were collected at various intervals following a single intramuscular injection of from 50 to 100 mg of streptomycin hydrochloride. Immediately before the intramuscular injection of the streptomycin, 200 c.c. of physiologic saline solution were injected into the peritoneal cavity of these animals to insure that fluid could be withdrawn for the peritoneal samples. Blood samples were withdrawn at hourly intervals for five hours and peritoneal samples at one-half hour, one,

two, and, in one animal, three hours following the single injection of physiologic saline solution into the peritoneal cavity. Fluid from the peritoneal cavity was unobtainable after three hours. Streptomycin concentration* was determined by a method described by Stebbins and Robinson¹². The levels of drug attained are shown in Fig 1. In order that samples might be obtained for longer periods of time after injection of the drug, further experiments were performed in which physiologic saline solution was injected into the peritoneal cavity immediately after withdrawing each peritoneal fluid sample for assay. Using this method, specimens were obtained hourly for six to eight hours after

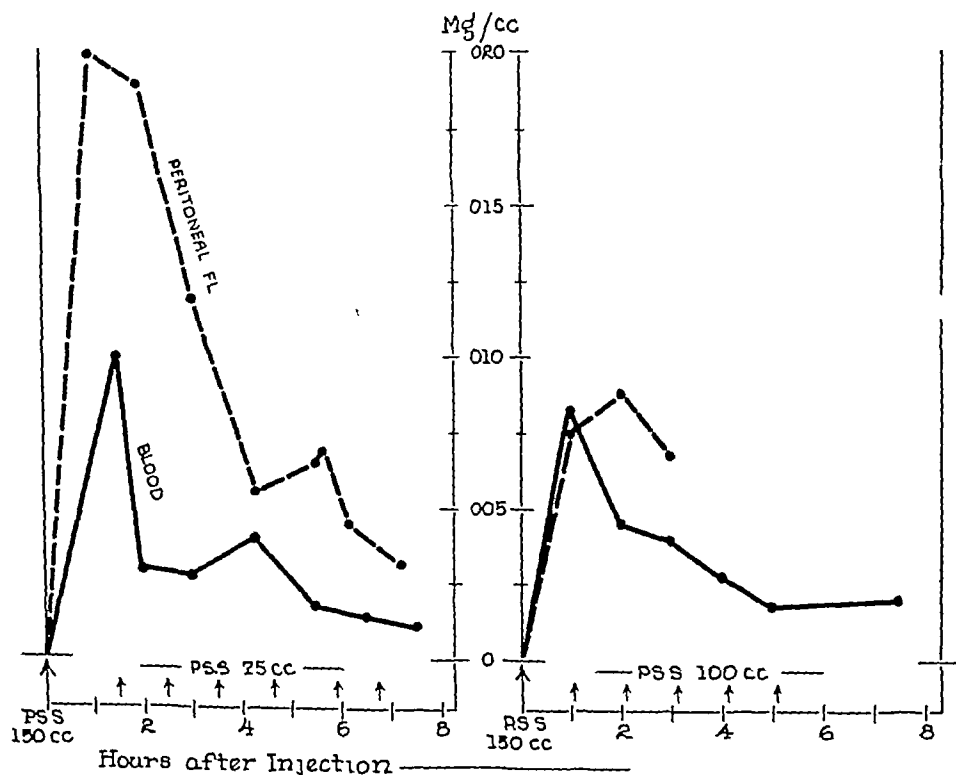


Fig 2—Concentrations of streptomycin in blood and peritoneal fluid following single intramuscular injection of streptomycin HCl 100 mg and interval intraperitoneal injections of physiologic saline solution.

a single injection of streptomycin. In spite of the constant dilution attending the addition of physiologic saline solution to the uninfected peritoneal cavity at hourly intervals, the concentration of the drug in the peritoneal fluid reached, and in most cases surpassed, the concentration in the blood. A detectable concentration persisted in the blood for as long as from seven to eight hours after injection (Fig 2). This indicates that streptomycin is excreted and/or destroyed much slower than is penicillin.

*Streptomycin concentration is expressed in milligrams according to the conversion factor used by Merck & Company, Inc., wherein 1,000 units are equivalent to 1 mg of the pure substance.

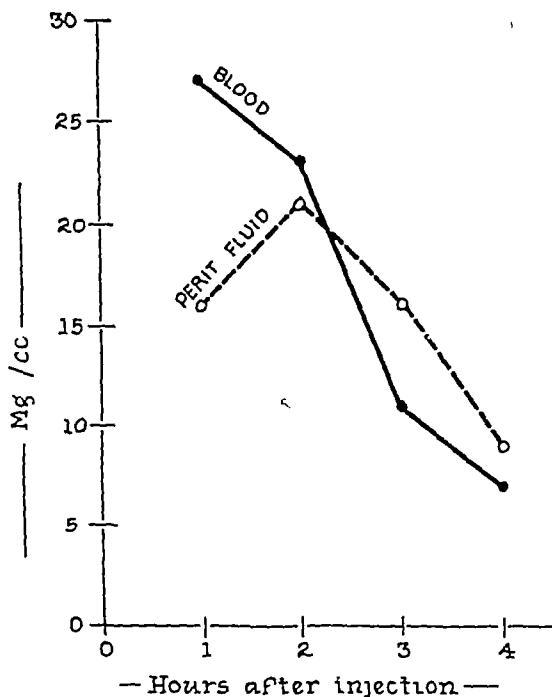


Fig 3—Composite graph showing streptomycin concentrations in blood and peritoneal fluid of five animals receiving 76 to 90 mg streptomycin HCl in distilled water intramuscularly every four hours

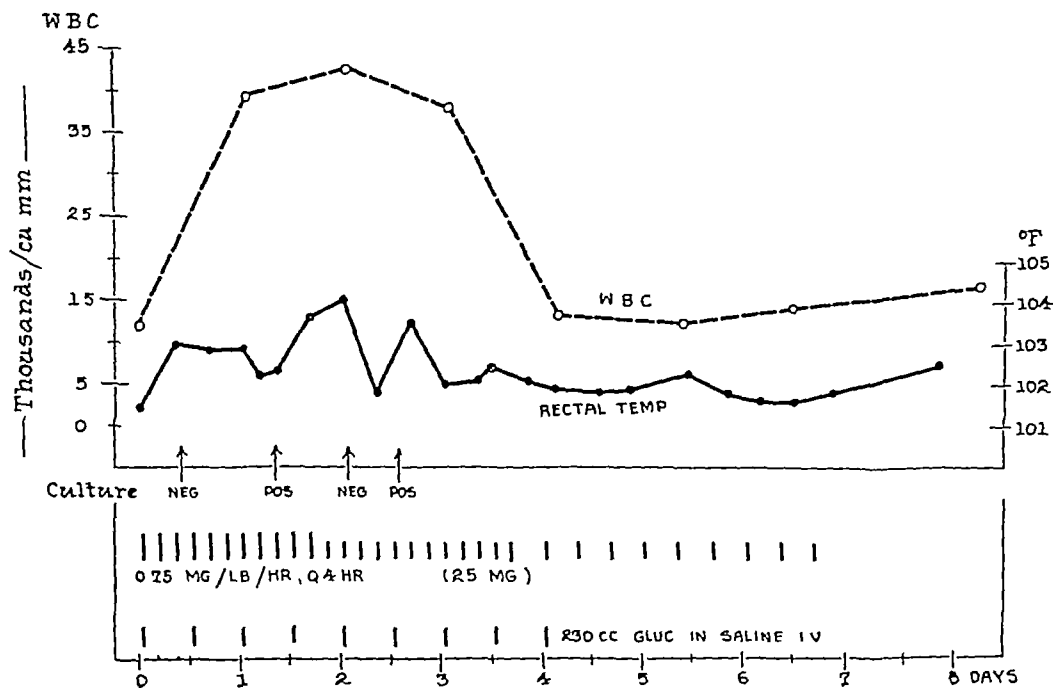


Fig 4—Typical course of treated animal

There is an appreciable amount of streptomycin in the blood and peritoneal fluid four hours after injection of the drug. Thus, when streptomycin is given every four hours, as was done in these experiments, the concentration of the drug shows a cumulative effect. There is shown in Fig 3 a composite graph of the blood and peritoneal fluid streptomycin levels of five animals receiving between 75 and 90 mg every four hours. Such repeated doses result in the maintenance of fairly high blood and peritoneal fluid streptomycin levels even after the dose has been decreased. In Table I is given a protocol of a dog treated for forty-eight hours with 85.7 mg every four hours and then with 25 mg every four hours for four injections. These data indicate that a fairly high concentration of drug was obtained and maintained in the blood during the entire course of treatment.

TABLE I ANIMAL TREATED WITH 85.7 MG OF STREPTOMYCIN HYDROCHLORIDE INTRAMUSCULARLY EVERY FOUR HOURS FOR FORTY EIGHT HOURS, THEN 25.0 MG EVERY FOUR HOURS FOR FOUR INJECTIONS

HOURS AFTER LAST INJECTION	STREPTOMYCIN LEVEL IN BLOOD (MG PER CC)
1	0.025
2	-
3	0.010
4	0.008

The technique used to produce peritonitis, in the experiments in which streptomycin was tested, is one which was introduced by Bower and co-workers¹ and modified by Fauley and his associates.⁴ The latter technique was followed exactly except that streptomycin was used instead of penicillin. Each animal received 0.75 mg of streptomycin per pound of body weight per hour every four hours for forty hours, beginning one hour after operation. During the following forty-eight hours 25 mg were given every four hours, and for the next three days the same dose was administered, but the interval was lengthened to eight hours. The typical postoperative course of such an animal is shown in Fig 4.

TECHNIQUE

Dogs were selected at random, excluding pregnant dogs, dogs weighing less than twenty-two pounds, and dogs previously operated upon. The animals were starved for twenty-four hours before beginning the experiment. The abdomen was shaved, scrubbed, painted with iodine and alcohol, and draped. Aseptic technique was rigidly observed. Under intravenous nembutal anesthesia (24 mg of nembutal per kilogram of body weight) the abdomen was entered through a right rectus incision and the appendix drawn into the wound. Mesenteric attachments were divided, and the appendiceal vessels were clamped, divided, and ligated with fine silk. The base of the appendix was tightly tied with umbilical tape, the viscera replaced, and the wound closed in layers with silk. No drains were used and no dressings applied. Immediately after closure of the wound each animal received 55.0 cc of castor oil by stomach tube. This has been shown to stimulate peristalsis and to aid in the perforation of the appendix and spread of infection.^{13, 14}

The animals received 100 c.c. per pound of body weight of a solution containing 2.5 per cent glucose and 0.45 per cent saline intravenously immediately after operation and every twelve hours thereafter for five days or until death. Rectal temperatures were recorded every eight hours and the white blood cell count was recorded every twelve hours. The animals received nothing by mouth for the first four days. Necropsy was performed on all fatalities shortly after death. The animals that survived were examined not earlier than twenty-one days after operation. All animals operated on are included in the series. Animals living twenty days were considered to have recovered.

Ten animals were used as controls. Of these, seven died of acute diffuse peritonitis within five days after operation, three recovered, a mortality of 70 per cent. In the experiments of Fauley and co-workers,⁴ twenty-five of twenty-seven control animals died, a mortality of 92.6 per cent. The typical post-operative course of one of our controls is shown in Fig. 5.

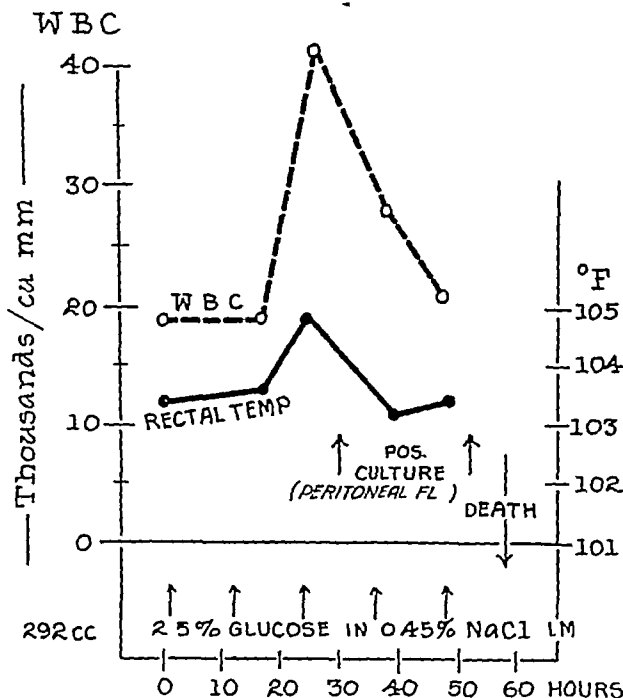


Fig. 5—Typical course of control animal.

Ten animals were treated with streptomycin in the manner described. Of these, four died within forty-nine hours after operation of acute diffuse peritonitis. Six animals lived more than twenty days postoperatively. Thus, the mortality in the treated animals was 40 per cent. The results are difficult to compare with other series^{1, 4} because of discrepancy in the control mortality. The survival rate of the treated animals compares favorably with that obtained by other methods of treatment^{1, 4}. It is believed that streptomycin may be of value in the treatment of peritonitis since high concentrations of the drug are obtained

in the peritoneal fluid and since the mortality in this series indicated that approximately 60 per cent of the animals treated may survive when streptomycin is administered. It is realized that the dosage used in these experiments does not represent the maximum dosage that can safely be administered.

CONCLUSIONS

1 Streptomycin was found in significant amounts in the peritoneal fluid of normal dogs and dogs with acute diffuse peritonitis.

2 The survival rate of the control animals was 30 per cent as compared with a survival rate of 60 per cent for the streptomycin-treated animals.

REFERENCES

- 1 Bower, J O, Burns, J C, and Mengle, H A. Prontosil and the Treatment of Spreading Peritonitis in Dogs, *J Lab & Clin Med* 24 240, 1938
- 2 Corry, D C, Brewer, A C, and Nicol, C. Postoperative Treatment of Appendicular Peritonitis With Sulfanilamide and Its Derivatives, *Brit M J* 2 561, 1939
- 3 Domagk, G. Ein Beitrag zur Chemotherapie der bakteriellen Infektionen, *Deutsche med Wchnschr* 61 250, 1935
- 4 Fauley, G B, Duggan, T H, Stormont, R T, and Pfeiffer, C C. The Use of Penicillin in the Treatment of Peritonitis, *J A M A* 126 18, 1944
- 5 Lockwood, John S, and Ravdin, I S. The Prophylactic Use of Sulfanilamide in Abdominal Surgery, *SURGERY* 8 43, 1940
- 6 Lockwood, J S, and Rhoads, J E. The Use of Sulfanilamide in the Treatment of Peritonitis, *S Clin North America* 19 1457, 1939
- 7 Ravdin, I S, Rhoads, J E, and Lockwood, J S. The Use of Sulfanilamide in the Treatment of Peritonitis Associated With Appendicitis, *Ann Surg* 3 53, 1940
- 8 Ravdin, I S, Lockwood, J S, and Rhoads, J E. Symposium on New Trends in Surgery, the Results of Sulfonamide Prophylaxis in the Surgery of the Large Bowel, *S Clin North America* 22 1585, 1942
- 9 Robinson, H J, Graessle, O E, and Smith, D G. Studies on the Toxicity and Activity of Streptomycin, *Science* 99 540, 1944.
- 10 Robinson, H J, Smith, O G, and Graessle, O E. Chemotherapeutic Properties of Streptomycin, *Proc Soc Exper Biol & Med* 57 226, 1944
- 11 Schatz, A., Bugie, E, and Waksman, S A. Streptomycin A Substance Exhibiting Antibiotic Activity Against Gram positive and Gram negative Bacteria, *Proc Soc Exper Biol. & Med* 55 66, 1944
- 12 Stebbins, E B, and Robinson, H J. A Method for Determination of Streptomycin in Body Fluids, *Proc Soc Exper Biol & Med* 59 255, 1945
- 13 Steinberg, Bernard. *Infections of the Peritoneum*, New York, 1944, Paul B Hoeber, Inc
- 14 Steinberg, B, and Martin, Ruth. Diffusion and Localization of Experimental Infections of the Peritoneum, *Surg, Gynec & Obst* 79 457, 1944
- 15 Zintel, H A, Flippin, H F, Nichols, A C, Wiley, M. M., and Rhoads, J E. Studies on Streptomycin in Man. I Absorption, Distribution, Excretion, and Toxicity, *Am. J M Sc* 210 421, 1945

TRAUMATIC ANEURYSMS

A STUDY OF FORTY-THREE CASES IN AN OVERSEAS GENERAL HOSPITAL

LIEUTENANT COLONEL HOLLIS L. ALBRIGHT AND MAJOR LAURENCE A. VAN HALE
MEDICAL CORPS, ARMY OF THE UNITED STATES

EXPERIENCES with vascular injuries early and late have mounted steadily during the progress of World War II, in a striking parallel to those recorded by the surgeons of World War I. Recognition that then problems were similar, that then management was good, and essentially the same, did much to dispel the confusion present in our approach to the care of these patients. The Royal Society of Medicine Library in London readily provided a list of over 100 publications on traumatic aneurysms alone, appearing between 1915 and 1920.

As the wounded soldier was evacuated to the Vascular Centers in the Zone of Interior, in each medical installation these pulsating vascular injuries had to be evaluated and promptly recognized and necessary measures of control of complications that might endanger the soldier during his further transit, instituted.

Case 1 is reported to illustrate some of the severe complications commonly confronting the patient with a traumatic aneurysm.

CASE REPORT

CASE 1—A 21 year old paratrooper sustained a penetrating shell fragment wound of the left upper posteromesial thigh six hours after jumping into France on D Day. Profuse bleeding was controlled by a pressure dressing. Sulfadiazine and penicillin were begun on the evacuation beach.

On his arrival at the general hospital, seven days later, the débrided wound was unremarkable, and the general condition was good. Roentgenogram revealed a 10 by 8 mm fragment in the anterior mid thigh.

Ten days after injury severe secondary hemorrhage of approximately 1,000 cc required emergency control by pressure, transfusions of blood and plasma, and exploration of the wound. The profunda femoris vessels were intact. The wound was lightly dressed with petrolatum gauze.

On the twenty fourth day an expansile swelling and palpable thrill were noted over the femoral vessels in the upper third of the thigh. A diagnosis of arteriovenous aneurysm of the superficial femoral artery and vein was made.

Dusky cyanosis of the dependent leg was noted on the thirty ninth day. There was no pain.

On the sixty fourth day, while awaiting evacuation to the United States, the patient complained of steady severe pain. The mass had enlarged, become more tense, and extended down the inner thigh.

Quadruple ligation of the femoral artery and vein distal to the profunda femoris vessels was done on the sixty fourth day after injury. A large aneurysmal sac, 18 by 12 by 10 cm, filled with clot, was excised together with the vessel segments (Fig 1). The foreign body was removed. Daily paravertebral blocks gave but temporary improvement in the cool, ischemic foot with evanotic toes. On the fourth postoperative day, a left lumbar sympathectomy was done, with removal of the third, fourth, and fifth ganglia. The foot became strikingly warm and recovery henceforth was uneventful (Fig 2). At the time of his return to the Zone of Interior, fifty six days later, he was symptom free.

General Considerations—Forty-three patients with aneurysms were studied in this general hospital in England during the eleven months from D-Day June 6, 1944, to V-E Day May 8, 1945. No patient had more than one aneurysm.



Fig 1—Arteriovenous aneurysm of the superficial femoral artery and vein, from the upper third of the thigh. Note the central communication which led to the large clot-filled aneurysmal sac 18 by 12 by 10 cm.



Fig. 2

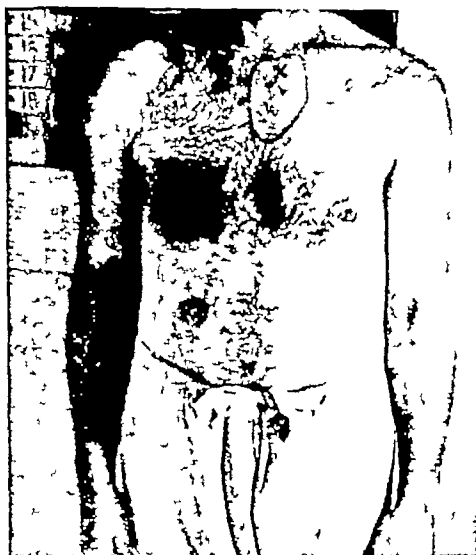


Fig 3

Fig 2—The patient (Case 1) four weeks after excision of the aneurysm and postoperative lumbar sympathectomy on the fourth day. The patient was symptom free and there was no edema.

Fig 3—Patient with signs of congenital aneurysm that is ductus arteriosus. Tiny shell fragment wound sustained over sternum. No evidence of intrathoracic foreign body or injury. The patient was sent to the hospital because of traumatic arteriovenous aneurysm. Area of harsh to and-fro bruit is outlined.

There were twenty-three arterial and twenty arteriovenous in type. Fourteen patients (three with arterial and eleven with arteriovenous aneurysms) were returned to the Zone of Interior without operation, because the aneurysm was regarded as relatively stabilized and free from complications. Nine patients previously operated upon in forward institutions were studied postoperatively. Twenty patients (eleven with arterial and nine with arteriovenous aneurysms) were operated upon in this general hospital. One patient (Fig 3) sent to the hospital because of a traumatic intrathoracic aneurysm was found on study to have a congenital aneurysm. This explained the harsh to-and-fro murmur over the great vessels, following a tiny superficial shell fragment wound over the sternum, with no opaque intrathoracic foreign body and no possible wound of exit.

The policy of delay in treatment of the uncomplicated aneurysm in order to allow development of the collateral circulation, as advised by War Department Circular No 235, June 12, 1944, and as generally advised by American and British surgeons (Holman,¹ Elkin,² Pemberton and Black,³ Bigger,⁴ Maybury,⁷ and Ogilvie⁸), was followed. Attention was directed (1) toward accuracy of diagnosis, (2) to the timing of necessary surgical intervention, (3) to the importance of specific preoperative studies and treatment, (4) to the operative technique, and (5) to postoperative measures guarding against limb mortality and morbidity.

A missile, shell fragment, or bullet passing through a vessel either divides it completely or partially transects the wall. The completely divided vessel requires early treatment. Most patients will bleed to death unless a tourniquet is applied or the vessel secured. Amputation may be necessary later. These patients do not develop pulsating hematomas or their later counterpart, traumatic aneurysms.

Partial division of an artery, or artery and vein, if treated expectantly, and it usually is, will lead to the development of a pulsating hematoma, thence to a traumatic aneurysm. The spasm in the vessel causes the rent in the wall to gape, and the vessel continues to bleed into the tissues. Bleeding ceases only when the pressure in the hematoma is equal to the arterial pressure of the involved vessel. The amount of bleeding and the size of the hematoma depend on the resistance of adjacent tissues and upon the size of the artery. The more tense the tissue planes the smaller the hematoma. A clot may temporarily seal the gap in the vessel wall, only to give way days or weeks later. Similarly, a contused portion of the wall may later give way (Maybury⁷). If the wound is large and gaping the vessel must be secured to prevent fatal hemorrhage, and the patient will not develop a pulsating hematoma.

The pulsating arterial hematoma is seen typically as a firm, tense, moderately tender, painful, throbbing mass. It was smaller, less tense, tender and painful in the arteriovenous group, and its complications were fewer. Both types undergo similar changes during their transformation into an aneurysmal sac. The distal vessels usually remain patent. The central portion of the hematoma sooner or later becomes liquid and a pulsation appears. Organization of the

clot begins at the periphery eventually, to form in four to six weeks the endothelially lined sac membrane. There may be some ingrowth of collateral vessels, especially in the arteriovenous aneurysm. Contamination and infection may interfere with the deposition of firm fibrous tissue and permit of softened areas in the sac membrane predisposing to rupture. This may cause further hemorrhage, swelling, damaging pressure upon the collateral and main blood supply and upon adjacent nerves, leading to ischemia, gangrene, and severe sensory or motor disturbances. Infection must always be considered since all wounds are contaminated by the passage of the missile, and occasionally pieces of clothing, through the soiled perspiring skin.

Once the clot is absorbed and the sac membrane formed, the lesion becomes a traumatic or false aneurysm. This differs from a true aneurysm in that the wall of the aneurysmal sac is not made up of the three layers of the normal vessel wall, but only of lining endothelium and peripherally organized clot.

Thus, the pulsating hematoma is the precursor of all traumatic aneurysms. It is most characteristic in the patient with the arterial injury, and less characteristic and smaller in the patient with the arteriovenous injury. It will lead inevitably, in days or weeks, to a traumatic aneurysm. Operation is always required sooner or later, especially if the hematoma ruptures and exerts damaging pressure upon the adjacent structures.

In this series many diagnostic terms had been employed to describe these two basic lesions, the *traumatic arterial aneurysm* and *traumatic arteriovenous aneurysm*. The term pulsating hematoma is descriptive of a traumatic aneurysm, in its early stages. In fact, the hematoma is aneurysmal once it starts to pulsate, since its central portion then contains rhythmically flowing blood. Henceforth, for simplification and clarity, the terms arterial aneurysm and arteriovenous aneurysm will be used. The pulsating hematoma will be regarded as an early phase in the development of both.

A fistula alone is less commonly seen. An associated hematoma is nearly always present. It was demonstrable in all except the three patients with intrathoracic arteriovenous lesions. The simple fistula is seen more commonly in the congenital (ductus arteriosus), the mycotic aneurysm, and the very long-standing traumatic cases, wherein the sac opening may have been small and eventually obliterated by thrombosis and fibrous replacement.

The traumatic aneurysm was thought to be arterial alone, until 1757, when William Hunter⁹ first recognized an arteriovenous aneurysm as a direct communication between artery and vein. Holman,¹ in his prize-winning monograph, has given an extremely helpful review of the subject of arteriovenous aneurysm. Earlier surgeons at first ligated the proximal artery (the hunterian operation), only to meet with gangrene. Bramann,¹⁰ in 1886, analyzing 159 cases concluded that this ligation of the artery proximal to the fistula must be absolutely condemned. The collateral circulation will find its way into the fistula and not into the distal capillary bed. He favored quadruple ligation of the artery and vein with extirpation or plication of the sac. If the artery and vein are ligated proximally alone, this will be of temporary benefit, for the fistula will not be

cured. Again, collateral channels will readily send blood through the fistula rather than distally.

Quadruple ligation with excision of the aneurysm was advised by the Interallied Conference of Surgeons in Paris, in May, 1917, and is generally regarded as the procedure of choice, especially in the young patient of soldier's age. Ligation of the accompanying vein, even though uninjured, was recommended, to retard too rapid venous outflow from the limb. Additional methods may help the surgeon in certain instances. Quadruple ligation without excision may prove wisest when there is an ill-defined sac membrane and widespread inflammatory fibrosis. The intrasaccular method of obliterative endoaneurysmorrhaphy of Matas,¹¹ which he first reported in 1888, and the transvenous closure of the fistula are well-known and useful methods. In addition, attempts have been made to restore the blood flow through an injured major vessel, or at least to keep up the flow temporarily until an adequate circulation has been established. Parafinized cannulae were used with some success by Tuffier¹²⁻¹³ in 1915. The use by Blakemore, Lord, and Stefkó,¹⁴⁻¹⁶ since 1942, of vitallium tubes lined with a vein graft has proved encouragingly effective in animals and in two clinical patients. The suture of arterial wounds, anastomosis of severed arteries, and closure of fistulas between arteries and veins have in the past been hampered by thrombosis at the suture lines. Thrombosis has occurred, too, in the past within the cannulae. Heparin and dicoumarin are now available to minimize and prevent this complication. Vascular centers in both the forward and rear areas have been set up where these traumatic aneurysms can best be dealt with under most advantageous conditions.

Interruption of sympathetic pathways temporarily with novocain paravertebral block, and less commonly by permanent ablation, has been found increasingly useful in the treatment of the ischemic limb. Experience has supported the view that when ligation of a main artery in an extremity is inevitable, the risk of gangrene can be reduced by preliminary sympathectomy (Learmonth¹⁷ and White¹⁸), or by repeated paravertebral sympathetic block with novocain postoperatively. This releases vasospasm and allows the collateral channels to dilate. Gage¹⁹ reported the real value of developing and maintaining the collateral circulation in fifteen patients with arterial and arteriovenous aneurysms by either injection or ablation of the regional sympathetic ganglia. Veal²⁰ suggested that sympathectomy may prove additionally of value in the future nutrition of the limb, stating that with a leg at rest, in a warm environment, the circulation may be adequate and the patient symptom free, but it may be wholly inadequate under the stress of normal function and fluctuations in climate.

Collateral circulation must develop and enlarge by active growth. Capillaries must become arterioles and venules, gaps of lacerated tissues have to be bridged and repaired, the woody fibrous mass surrounding the hematoma of the aneurysm must be absorbed and infection overcome. Such repair takes time and must be allowed for in planning operations on traumatic aneurysms. When the collateral circulation is established, there is much to be said for deliberate

dilatation of the collateral vessels by sympathectomy. This plan followed in the Middle East and backed by other modern methods of caring for the ischemic limb has been giving excellent results.²¹

The British Center for Vascular Injuries has sent the following instructions to the forward areas, to develop three principles (Ogilvie⁸)

- 1 To bring the circulation to its maximum efficiency
- 2 To direct the blood current selectively toward the threatened limb
- 3 To reduce the demand of the starved tissues for oxygen to the lowest level compatible with survival

The instructions were as follows

- (1) Restore the blood volume and hemoglobin to normal by transfusion
- (2) Inject 250 c c of sodium chloride 2 per cent solution into a vein
- (3) Keep the limb below the level of the heart
- (4) Warm the body but keep the threatened limb cool by exposing it to air
- (5) Infiltrate the stellate or lumbar ganglia with novocain
- (6) Resect the ganglia, prior to a secondary operation on an artery, as for aneurysm

Simultaneous ligation of the vein is advised against, not because it is felt to be wrong, but because the only advantage it gives is believed to lie in passive congestion of the capillary bed, an effect that can be gained more simply by posture. Homans²² agreed with this, stating that ligation of the companion vein hitherto regarded as essential may prove to be of less importance than intermittent depression of the wounded limb. Lowering the limb 4 to 6 inches below the heart level elevates the venous pressure in the extremity just enough to keep the collateral supply of blood sufficiently long for complete deoxygenation (Blakemore and Lord¹⁰).

Bigger⁶ in a study of twenty-nine cases emphasized the likelihood of residual circulatory insufficiency. This has been noted in a high percentage of cases followed. He agreed that excision of the sac and quadruple ligation are the procedure of choice, guarding against recurrence of the fistula. However, he deplored the inevitable sacrifice of collaterals in excising the sac. He suggested that transvenous repair of the larger arteries be done if there are no contraindications, notably calcification of the vessel wall. This has been observed by x-ray within a few weeks of injury (Schroeder²³). Bigger believed that interruption of the sympathetic nerves may help prevent chronic circulatory deficiency distal to the ligation of the main vessel.

In World War II, Gnilorybov²⁴ on the Russian front reported his experience with 130 personally performed operations, 98 for "aneurysm" and 32 for pulsating hematoma. Ligation was done in two-thirds of the operations and suture in the remainder. No gangrene followed suture, whereas gangrene developed in 10 per cent of the ligations. Punin was quoted in a series of over 1,000 cases, he found little difference (7 per cent gangrene) with each method. Apparently no anticoagulants were used with arterial suture.

Kilhan²⁵ discussed the experience of the German surgeons on the Russian front with eighty-three fresh traumatic aneurysms, of which 72 patients were operated upon within twelve days. Of the seventy-two operated upon, thirteen died (18 per cent mortality), six because of the wrong diagnosis, that is the aneurysm was opened into, in the belief that it was an abscess. Arterial suture, end-to-end, with a vein graft where necessary was attempted in most cases, using ligation as a second choice. Amputation for hemorrhage and gangrene was necessary in a considerable, unstated, number of cases. The diagnosis was missed in eleven of the eighty-three cases. It was often missed because there was no record of the distal pulses having been examined, even though the injuries were close to large vessels. This high incidence of patient and limb mortality hardly seems to justify the conclusions advising early rather than delayed operations and arterial suture without anticoagulants in preference to ligation. Such is at radical variance with the established experience of surgeons of the allied countries.

Differential Features—The symptoms are few and may be common to both types. Pain is moderate, usually throbbing or buzzing in character. Claudication, coldness, weakness, and easy fatigability of the extremity, with paresthesias due to ischemic neuritis or paralysis due to pressure may be present. Severe, unremitting pain means impending complication. Shortness of breath is usually a later symptom in the arteriovenous patient.

The findings differ characteristically, however (Table I). Both types are evidenced by an expansile pulsating tumor (Figs 4 to 6). In the arterial aneurysm a thrill may or may not develop. It was present in eight of our twenty-three patients. The pathognomonic systolic bruit was present in all. There was little to no change in temperature of the extremity. The distal pulses and blood pressure are usually unchanged, unless the size of the hematoma mechanically occludes the artery. Compression of the proximal artery causes no slowing of the pulse or rise in blood pressure. The distal venous pressure usually shows no change. Ischemic neuritis may be present.

The arteriovenous aneurysm is characterized by a usually smaller and less tense swelling, a tremulous thrill, and a to-and-fro murmur with systolic accentuation. The larger the fistula the more pronounced is the thrill (Hol-

TABLE I. DIFFERENTIAL CHARACTERISTICS

ARTERIAL ANEURYSM	ARTERIOVENOUS ANEURYSM
Expansile mass usually larger, more tense, and tender	Expansile mass, usually small, less tense, and tender
Thrill inconsistent (8 of 20 cases)	Thrill, usually marked, present in all but the ductus arteriosus case
Systolic bruit	Continuous bruit with systolic accentuation
Distal pulse usually unchanged	Distal pulse diminished to absent
Distal blood pressure unchanged	Distal blood pressure showing marked drop
Temperature unchanged	Usually increased warmth of extremity
Pulse and systemic blood pressure little to no change	Usually moderately increased
Compression of proximal artery causes no slowing of pulse or rise in blood pressure	Compression of fistula on proximal artery causes immediate slowing of pulse and slight rise in blood pressure
Distal venous pressure unchanged	Distal venous pressure increased
Distal venous blood oxygen and carbon dioxide unchanged	Oxygen increased, carbon dioxide decreased

man¹) The thrill is produced by arterial blood under higher pressure coming suddenly in contact with low pressure venous blood, creating whirling eddies readily discernible through the vein wall at operation The distal pulse is diminished to absent and the distal blood pressure definitely reduced The extremity may be at first cool but usually shows increased warmth as the collateral channels develop Compression of the fistula (Marey, 1859¹) or of the proximal artery (Nicoladmi, 1875¹) causes characteristic slowing of the pulse, with less marked rise in the systemic blood pressure (Gunderman, 1915¹) This proved a valuable differential sign

The systemic effects are slight with the arterial aneurysm They may be considerable in the patient with arteriovenous aneurysm, depending on the size, location, and duration of the fistula The larger and more central the fistula and the longer it exists, the more likely cardiovascular changes are to develop Reid²⁶ first reported cases in which the circulatory effects of the fistula had resulted directly in cardiac decompensation and death There was tachycardia in four of our patients but no demonstrable cardiac dilatation or hypertrophy



FIG 4—A small arteriovenous aneurysm of the popliteal vessels with the patient prone.

Rarely the carbon dioxide and oxygen content of blood from a vein near the lesion is necessary to distinguish definitely between the two Some confusion may arise when the lesion is deep-seated or is surrounded by inflammatory thickening or extravasated blood (Pemberton and Black⁵) Dilated pulsating superficial veins have been described, but were not encountered in our twenty cases Only at operation was the involved vein seen to pulsate

In this series, study at the bedside with classifying charts yielded an unsuspected amount of helpful data Except for desirable thoroughness, little additional value was gained from arteriography, phlebography, or venous pressure readings No studies of the distal venous blood oxygen and carbon dioxide levels were made Arteriography was used but twice At the common femoral level, with direct operative exposure, the procedure was moderately extensive

and traumatic. It added little in determining the location and actual size of the fistulous opening. Phlebography was used twice to confirm the absence of a fistula.

No examination was considered complete without palpation of each wound for pulsation and thrill, and auscultation for bruit. This led to the discovery of unsuspected aneurysm in six patients. In five patients examination at intervals revealed the development of an arterial hematoma during their hospital stay. Such examination prevents small aneurysms from being overlooked and may avoid making the wrong diagnosis of abscess. Six deaths resulted from mistakenly opening into these "abscesses" in Killian's²⁰ series of seventy-two early operations upon German soldiers on the Russian front. Nothing can lead



Fig. 5—An arterial hematoma of the brachial artery. Brawny edema, cyanosis and paresthesias were present. Uneventful recovery followed quadruple ligation of the brachial vessels with evacuation of the hematoma.

to such a distressing situation creating an unavoidable emergency for which no preparation has been made. In the first case in this series, the only nonbattle injury, namely, a soldier who had sustained a gunshot wound through the shoulder one month previously, a mistaken diagnosis of axillary abscess was made. It was opened into with nearly fatal, exsanguinating hemorrhage. The subclavian artery could not be digitally compressed successfully with the arm abducted. We have confirmed this repeatedly since, in our tests of the collateral circulation of the arm. Once the arm was brought to the side the subclavian vessels were more on the stretch and could be compressed readily against the



Fig. 6—An arterial aneurysm of the brachial artery seven weeks after injury. The course of the bullet is indicated. There was fixation of the elbow at 90 degrees with hemorrhagic infiltration of the median nerve and distortion by pressure. The contracture was difficult to correct postoperatively.

first rib, with control of the hemorrhage. Following ligation of the second portion of the axillary artery, the patient happily made an uneventful recovery. Davis²⁷ mentioned operating upon a painful brachial mass in a febrile soldier with intent to incise and drain the "abscess." On exposure, the mass was seen to pulsate, the correct diagnosis of pulsating hematoma of the brachial artery was made, and incision withheld.

The typical story of these patients was that of usually an infantry soldier sustaining a small puncture wound by a mortar or high-explosive shell fragment or bullet. The wound of entrance rarely lay directly over the involved vessel or vessels, usually some inches away. The path of the missile was usually oblique

and, in all cases, there was partial rather than complete severance of the vessel wall. Initial bleeding, although brisk to severe in twenty-two patients, usually subsided after several minutes. A tourniquet was used in only nine cases. A compression bandage proved sufficient in the remaining

The soldier usually had to wait in a foxhole for the company aid man, or drag himself some distance to a battalion aid station, where sulfanilamide powder was applied locally and penicillin injections begun, to be maintained during transit. Early débridement was done, followed in seven to ten days by secondary wound suture. Days to weeks later, a pulsating mass, usually painful, developed.

The wounds were surprisingly free from infection in forty-one cases. There were two cases complicated by gas gangrene, with one death and one recovery.

CASE REPORTS

CASE 2—On July 16, 1944, a 22 year old infantry corporal was struck by an 88 mm shell fragment in the left lumbar region, at the level of the second lumbar vertebra. The fragment coursed downward beneath the inguinal ligament, partially transecting the profunda femoris artery, to lodge deep in the lower third of the left thigh.

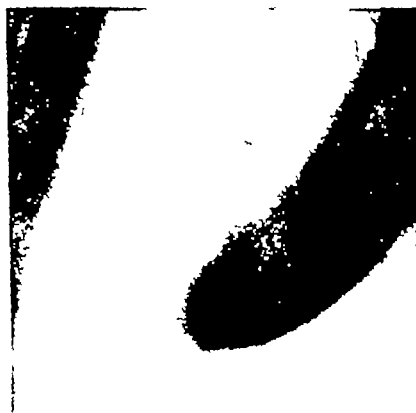


Fig 7—Extensive gas gangrene of the thigh in a patient with a large arterial hematoma of the profunda femoris artery. Note the deep pockets of gas. The shell fragment had entered the thigh via the left flank at the level of the second lumbar vertebra.

On arrival at the general hospital eleven days later, the patient was acutely ill. The temperature was 101° F, the pulse 114, the respirations 28. The left thigh was markedly swollen, with tender boggy induration of its entire posteromesial aspect. A rough thrill and systolic bruit were present over the femoral vessels just below the inguinal ligament. Roentgenogram revealed large pockets of gas deep in the thigh (Fig 7). Radical incision and drainage well away from the aneurysm and under ether anesthesia were done, with removal of infected clot and gangrenous muscle, namely, the adductor group. Active hemorrhage required proximal ligation of the common femoral artery and vein. The patient went into sudden collapse and died seven hours later. Post mortem examination revealed two pulmonary emboli (2.5 cm and 1.0 cm diameter) plugging the major pulmonary artery of the left lower lobe. The left femoral vein contained several nonadherent thrombi similar to those in the lungs. Cause of death was pulmonary embolism, arising from thrombophlebitis of the left femoral vein, superimposed upon extensive gas gangrene myositis of the left thigh.

CASE 3—A 26 year old infantry private first class developed gas gangrene myositis in the wound of exit, four days after a German rifle bullet entered just below the right antero superior spine, partially transected the common femoral vessels, and emerged in the right mid buttock in Nélaton's line. *Clostridium welchii* and *Clostridium sporogenes* were cultured. Radical incision, drainage, and débridement of the buttock wound were done, followed by six transfusions and uneventful recovery. The arteriovenous aneurysm showed no further complications. The Moschcowitz Matas test showed the collateral circulation of the foot inadequate. Intermittent compression of the common femoral artery by the patient was begun. The patient was transferred to the Zone of the Interior in the sixth week for eventual operation.

Age—Thirty-nine patients were under 30 years of age, and four were over 30. The youngest patients, six in all, were 19 years of age, the oldest was 37 years. The average age was 24 years. Experience has shown that the young patient certainly withstands ligation of major vessels with a much lower incidence of gangrene. However, the expressed attitude that "in these young patients practically any vessel in the body can be ligated with impunity" should be strongly discouraged. The real incidence of "postoperative sequelae," such as chronic circulatory deficiency with edema, claudication, and ischemic neuritis, contributes to prolonged recovery and limb morbidity.

Types of Injuries—Jagged, small, shell fragments of from either the high velocity 88 mm, mortar, land mine, or 20 mm type, caused the injuries in thirty-two patients. Ten were injured by the more cleanly transecting smooth rifle, pistol, or machine gun bullet. Five of the injuries were accidentally incurred while examining, cleaning, or destroying German weapons. A helmet fragment partially severed the occipital artery in the remaining patient. The jagged shell fragment usually causes a more complicated wound. It usually lodges in the tissue, carrying pieces of clothing with it, whereas the smooth bullet is prone to perforate the limb cleanly and is less likely to carry a piece of clothing, thereby reducing the prominence of infection.

Distribution of Injuries—In Table II is shown the location of these forty-three vascular injuries. Twenty-five aneurysms (58 per cent) involved the lower extremities, nine the upper extremities, five were within or near the thoracic cage, three the neck, and one the head. Of the twenty-nine operations, nineteen were of the lower extremities, namely, ten arterial and nine arteriovenous. Twenty of these operations were in this general hospital, eleven arterial and nine arteriovenous. Nine patients had been operated upon prior to admission here. The remaining fourteen patients were returned to the Zone of Interior with uncomplicated aneurysms, for later operation.

The indications for operation are shown in Table III. Nineteen patients had an expanding hematoma, 44 per cent of the entire series. Twelve were arterial and seven arteriovenous. Eight patients had definite ischemia for an average of thirteen days before operation. The earliest intervention was three days, the longest thirty-two days later.

Three patients had sudden severe external hemorrhage in bed, eight, nine, and ten days after injury. The blood loss was estimated at 400 c c in one patient and nearly 1,000 c c in two. Three patients had sudden interstitial rupture

TABLE II SITES OF ANEURYSMS

	ARTERIAL		ARTERIOVENOUS	
	OPERATED	NONOPERATED	OPERATED	NONOPERATED
Head and neck				
Occipital	1			
Common carotid		1	1	1
Thoracic				
Ductus arteriosus				1
Subclavian		2		2
Upper extremity				
Axillary	2			
Brachial	4			1
Ulnar	2			
Lower extremity				
Common femoral				1
Profunda femoris	2		1	
Superficial femoral	2		3	2
Popliteal	2	1	1	1
Posterior tibial	4		4	1
Total	19	4	10	10

of the aneurysm with marked enlargement, requiring early intervention. Two patients had tense hematomas directly beneath a thin unstable scar, suggesting the possibility of rupture during further transport of the patient.

One patient arrived with a pulseless extremity and gangrene four days after sustaining a compound fracture of the femur. Immediate removal of the cast revealed a huge pulsating hematoma of the lower thigh, stretching to skin tightness beneath the cast and containing an estimated 1,000 cc of clotted blood. Mid-thigh amputation was unavoidable. A posterior laceration of the popliteal artery was found. The second patient developed gangrene of the lower extremity ten days after ligation of the external iliac vessels for an expanding hematoma of the femoral artery (see Operative Procedures). Operation was unavoidable in one patient with gas gangrene myositis involving the entire thigh and aneurysm of the profunda femoris artery. The outcome was fatal, as reported. Marked flexion contracture was present in three cases, namely, two of the elbow and one of the knee (see Discussion). The first patient of this series was operated upon under the mistaken diagnosis of axillary abscess, discussed

TABLE III INDICATIONS FOR OPERATION (TWENTY NINE CASES)

INDICATIONS	ARTERIAL GROUP	ARTERIOVENOUS GROUP
Expanding hematoma with		
Ischemia	6	2
Pressure neuropathy	4	4
Flexion contracture	2	1
Acute rupture with external hemorrhage	1	2
Thin unstable scar overlying aneurysm	2	
Gangrene		
Before aneurysmectomy	1	
After aneurysmectomy		1
Gas gangrene myositis	1	
"Abscess"	1	
Uncomplicated 2.5 cm. aneurysm of distal ulnar artery	1	
Total operations	19	10

previously. An uncomplicated tiny aneurysm of the ulnar artery at the wrist was removed, with early return of the patient to duty.

Associated Nerve Injuries—Twenty-two patients, 50 per cent of the entire group, showed evidence of injury to accompanying nerves, namely, either paralysis, partial or complete, or sensory disturbances (Table IV). Operative findings repeatedly showed that neurologic examination could not disclose accurately beforehand whether the nerve injury was due to pressure of the aneurysm, with distortion, hemorrhagic infiltration, extra or intraneural fibrosis, or due to partial or complete severance of the nerve.

TABLE IV ASSOCIATED NERVE INJURIES IN FORTY THREE CASES

ARTERIAL ANEURYSM GROUP			
<i>Operated (14 cases)</i>		<i>Unoperated (3 cases)</i>	
Pressure disturbances	8 cases	Paralysis	
Ulnar	1	Partial	
Ulnar and median	1	Peroneal, sensory	1
Radial and median	1	Ulnar component of brachial plexus	1
Median	2	Complete	
Posterior tibial	2	Hypoglossal and axillary nerve to deltoid muscle	1
Posterior tibial and peroneal	1		
Severance of nerve	3 cases		
Partial			
Median, with neuroma	1		
Complete			
Ulnar	1		
Posterior tibial	1		
ARTERIOVENOUS ANEURYSM GROUP			
<i>Operated (2 cases)</i>		<i>Unoperated (6 cases)</i>	
Pressure disturbance		Paralysis	
Recurrent laryngeal nerve brachial plexus, sensory component of		Partial	5
radial nerve	1	Recurrent laryngeal	1
Severance of nerve-partial		Ulnar sensory	2
Laceration of lateral cutaneous nerve of thigh	1	Sensory inner thigh	1
		Posterior tibial nerve	1
		Complete	1
		Median	1

At operation, the nerve trunk was ecchymotic and infiltrated with blood in three patients. There was binding extraneural fibrosis in three. One traumatic neuroma arose from an incompletely severed median nerve, and one from a completely divided posterior tibial nerve. A large gap existed in a divided ulnar nerve (2.5 cm. destroyed) and a posterior tibial nerve (3 cm. destroyed). Two patients who were not operated upon had signs of incomplete division of segments of the brachial plexus.

In ten instances the following adjuvant procedures were done in conjunction with eradication of the aneurysm. Neurolysis was done in seven cases, separating by knife dissection the bound, distorted nerve trunk from the inflammatory fibrous tissue surrounding the aneurysm. The nerve was restored to its normal position following evacuation of the hematoma and removal of the aneurysm sac. The nerve was carefully palpated for areas of increased fibrous thickening. Endoneural injection of 1 to 2 cc. of normal saline solution was then made in the hope of minimizing or preventing adhesions. Primary suture of the nerve was done in two cases, following excision of the neuroma, one median and one

posterior tibial Eight zero silk was used, and the anastomosis was wrapped in an inverted vein segment (Fig 8) In the third patient, who had a severed ulnar nerve with 3 cm shot away, anastomosis was deferred because of the considerable reaction from the large expanding hematoma and adjacent fractures of the olecranon and of the lower end of the humerus The ends of the nerve were isolated for future repair and neurolysis of the median nerve was performed



Fig 8—Removal of cast three weeks after excision of an expanding hematoma of the posterior tibial artery and primary repair of the severed posterior tibial nerve. Wound of exit is seen on the outer calf

Preparation for Operation—Following initial studies all patients were given repeated transfusions to bring the blood hemoglobin level to 100 per cent This provided optimal oxygen-carrying capacity to the blood coursing through impaired vascular channels, and aided in the development of collateral circulation in both the preoperative and postoperative patient Many transfusions were often necessary due to debility arising from associated fractures, and chest, abdominal, and soft tissue injuries The fourteen patients on whom no operations were performed were sent on to the Zone of the Interior with optimal blood levels Instructions were given for intermittent compression of the proximal vessels by the patient himself to aid further in the development of the collateral circulation

Testing of the collateral circulation was routinely done With due recognition that no single test is absolute, it was felt that together with the warmth and color of the limb, the Moschcowitz-Matas test, descriptively termed by us the "blanching and pinking test," proved the most reliable in evaluating preoperatively the state of the collateral circulation

"Elevate the extremity to an angle of 30 degrees, compress the artery with the fingers just proximal to the point of injury, and apply an Esneareh

bandage from the fingers or toes up to the point of injury. After maintaining bandage and pressure for five minutes, release the bandage while maintaining digital pressure on the artery. The limb should flush down to the fingers and toes within, at most, three minutes, preferably within one minute.¹²⁸

If the test revealed insufficiency of the collateral circulation, further delay of operation was indicated except under most urgent conditions. Intermittent compression of the main artery was continued. Novocain interruption of the sympathetic nerves was performed for study of the possible benefit of preliminary sympathectomy.

Operative Procedures—Cross-matching of the blood was then done and two units were made available at operation. A pneumatic tourniquet was placed but its use was kept at a minimum by the operative method employed. The affected limb was kept slightly lower than the heart, to aid in slowing the venous return. Anatomic exposure by knife dissection, first of the proximal vessels and nerves, then of their distal components, was the procedure of choice in our twenty cases. In our experience it proved vastly superior to direct approach over the aneurysm, under prolonged tourniquet control. The exposure is more generous, the procedure more orderly and under better control, with less trauma and better safeguard against possible injury to dislocated vessels and nerves. The artery, vein, and nerve were isolated in their normal relations, the vessels controlled by tape proximally and distally, thereby securing the main blood supply. Then the aneurysm sac was dissected, the clot evacuated, and the injury to the vessels and nerves visualized, despite the distortion due to widespread inflammatory fibrosis. Wherever possible, excision of the aneurysmal sac and of the injured segment of artery and corresponding segment of vein, injured or uninjured, was done. Should bleeding from the collateral vessels between the sac and the surrounding tissues become troublesome, then the tourniquet could be tightened for a shortened period. The collateral circulation was further tested at operation by the Coenen test, namely, by releasing the distal end of the divided artery and noting the briskness of retrograde flow. This aided in deciding the need for postoperative sympathetic blocks, temporary or permanent. In our twenty cases, the flow was moderate to brisk in all patients.

Exposure and control of the vessels proximal and distal to the aneurysm repeatedly proved to be the simplest part of the procedure. The remainder at times proved quite harrowing. The sac membrane, though usually dissectible, may be ill formed, thin, or densely incorporated in the surrounding structures with alternate vascular channels and no plane of cleavage. It may at times prove wiser and less damaging to leave a portion of the sac than to endanger the collaterals by persisting in attempts to remove the densely adherent portion. Quadruple ligation with excision of the fistula and damaged vascular segment will cure the fistula, whether or not the entire aneurysm sac is removed.

“Avoidance of serious loss of blood requires skill and great familiarity with the lesion.”²⁸ No undue bleeding was encountered in the group with arterial aneurysms. In the group with arteriovenous aneurysms, even with control of the proximal and distal vessels, bleeding occurred in several patients from sui-

rounding dilated vessels and blind deep sources difficult to control. Ten patients, five with arterial and five with arteriovenous aneurysms, were given from 375 to 1,500 c c (one to four units) of blood at operation (Table V). All but three patients were given transfusions at operation.

TABLE V TRANSFUSIONS GIVEN DURING OPERATION (TWENTY NINE CASES)

NUMBER OF TRANSFUSIONS GIVEN		NUMBER OF CASES
None		3
One (375 c c)	Arterial	3
	Arteriovenous	11
Two	Arterial	5
	Arteriovenous	3
Three	Arterial	2
	Arteriovenous	2
Four	Arteriovenous	1
Total		29

With both arterial and arteriovenous lesions, the operative treatment was essentially the same. Quadruple ligation after excision of the damaged vascular segments, with removal of the aneurysm and foreign body, comprised the desired procedure. The vessels were transfixed with silk. Nonabsorbable sutures of cotton, silk, or nylon were used throughout, with greater reliance on silk for the vascular ligatures. A mixture of sulfanilamide (15 Gm.) and penicillin (100,000

TABLE VI VASCULAR OPERATIONS ON TWENTY NINE PATIENTS

	ARTERIAL ANEURYSM	ARTERIOVENOUS ANEURYSM
Ligation of proximal and distal artery, plus		
Evacuation of hematoma	2 Axillary	None
Excision of aneurysmal sac	1 Femoral	None
Quadruple ligation Alone	1 External iliac	
	1 Common femoral	
	1 Profunda femoris	
	1 Popliteal	
Plus evacuation of hematoma	11 { 3 Posterior tibial	4 { 2 Femoral
	3 Brachial	1 Popliteal
	1 Ulnar	1 Posterior tibial
	1 Occipital	
Plus excision of aneurysm	3 { 1 Brachial	5 { 1 Common carotid
	1 Ulnar	artery plus jug
	1 Posterior tibial	ular vein
		1 Femoral
		1 Profunda femoris
		2 Posterior tibial
Plus endoaneurysmorrhaphy and partial excision of sac	None	1 Posterior tibial
Amputation		
Primary	1 Mid thigh	None
Secondary	1 Mid thigh	None

units) was sprinkled lightly in the wound. Primary closure was done in all patients, with drainage of one femoral aneurysm for doubtfully complete hemostasis.

In twenty-five patients both the artery and vein were divided and ligated (Table VI). Three patients had division of the artery alone, above and below, two axillary and one superficial femoral aneurysms. The remaining patient required mid-thigh amputation three hours after admission, for gangrene following a huge pulsating femoral hematoma, exerting pressure within the four-day old cast. Endoaneurysmorrhaphy, plus quadruple ligation, was done in one patient to control troublesome deep bleeding from collateral vessels.

Neither the gangrene-producing hunterian ligation of the proximal artery alone nor the incomplete proximal ligation of the artery and vein predisposing to persistence of the fistula was done. Arterial repair, end-to-end suture, and transvenous suture of the artery were not feasible in any of these patients because of the inflammation, extravasation of blood, and fibrosis.

Eighteen ligations involved the lower extremity, namely, one external iliac, seven femoral, two popliteal, and eight posterior tibial (Table VII). There were eight of the upper extremity, namely, two axillary, four brachial, and two ulnar. There were two of the neck, namely, one of the common carotid artery and internal jugular vein, and one of the occipital artery.

TABLE VII. VESSELS LIGATED

Head and Neck			
Occipital			1
Common carotid artery			1
and			
Internal jugular vein			
Upper Extremity			
Axillary			2
Brachial			4
Ulnar			2
Lower Extremity			
External iliac			1
Femoral			7
Common femoral	1		
Superficial femoral	4		
Profunda femoris	2		
Popliteal			3
Posterior tibial			8
Total			29

Secondary mid-thigh amputation was required for gangrene ten days after ligation of the external iliac vessels, six inches proximal to an expanding femoral hematoma of thirteen days' duration. Although the distal femoral vessels were ligated, the hematoma under tension was not evacuated. Discoloration, swelling, pain, and ischemia had been present preoperatively. The importance of proximal ligation close to the lesion, preferably just distal to an arterial tributary, and of early release of the damaging tension in the expanding hematoma is emphasized.

Ten patients had perforating wounds with no remaining foreign body. Nineteen patients had penetrating wounds, with retained shell fragments (Table VIII). In twelve the foreign bodies were removed at operation. In seven cases

TABLE VIII FOREIGN BODIES

	PERFORATED WOUND	PENETRATING WOUND	FOREIGN BODIES PRESENT	FOREIGN BODIES REMOVED	FOREIGN BODIES NOT REMOVED
Arterial aneurysm	7	12	12	6	6
Arteriovenous aneurysm	3	7	7	6	1
Total	10	19	19	12	7

the foreign body was not removed. No prolonged search was made if the foreign body was asymptomatic, less than 1 cm in diameter, did not impinge on a nerve, or was not imbedded in bone.

Postoperative Treatment—A nonconstricting bandage was generally used. A circular cast was applied in three patients with gently corrected flexion contracture and two with nerve suture, to avoid tension on the suture line. With motor nerve paralysis, that is, wrist drop and foot drop, the part was maintained in neutral position by splinting. A cradle with light, preferably to the abdomen to aid vasodilation, plus morphine, and instructions to inspect the dressing for bleeding hourly for eight hours were routine. The hemoglobin was restored to 100 per cent. This required multiple transfusions in several of the patients with arteriovenous aneurysms.

Inspection of the limb was made every few hours for the first three days. Coldness, blanching of the fingers or toes, pain, and diminished distal pulsations were treated with paravertebral sympathetic blocks daily or as often as every eight hours. Reliance was placed upon interruption of the sympathetic pathways for the release of vasospasm. Such provided a factor of safety in sustaining the vitality of the threatened limb. However, temporary block with novocain was indicated in but ten patients (Table IX). It was used preoperatively in two and postoperatively in eight patients.

TABLE IX. SYMPATHETIC INTERRUPTION

	NOVOCAIN BLOCK		SYMPATHECTOMY	
	PREOPERATIVE	POSTOPERATIVE	PREOPERATIVE	POSTOPERATIVE
Arterial Aneurysm	1	3		
Arteriovenous aneurysm	1	5	1	2
Total	2	8	1	2

The Ochsner technique was used, injecting 5 to 10 c c of 1 per cent novocain through each of four needles close to the first four lumbar ganglia. Injection of the first three thoracic sympathetic ganglia was done in one patient.

Lumbar sympathectomy was done in three arteriovenous patients. One was done preoperatively in preparation for ligation of the common femoral vessels (Fig 9). The collateral circulation of the foot was inadequate by testing. The aneurysm arose from the origin of the profunda femoris vessels, and ligation of the common femoral vessels was happily avoided. One patient, despite repeated paravertebral blocks, had a recurrently cold ischemic foot four days after excision of an aneurysm of the superficial femoral artery and vein. Sympathect-

tomy was done on the fourth day with gratifying warmth of the leg and uneventful recovery (Fig 2) In the third patient sympathectomy was done for its possible nutritive value twenty days after excision of an aneurysm of the superficial femoral artery Muscular pains and coolness persisted despite 100



Fig 3—A patient three weeks after excision of an arteriovenous aneurysm of the profunda femoris vessels at their origin Preliminary lumbar sympathectomy was done three weeks before excision, because of poor collateral circulation tests Wound of entrance can be seen in lateral thigh The shell fragment was removed

per cent hemoglobin, postoperative blocks, and physiotherapy As an adjuvant measure, this procedure seemed to help in the further improvement of the patient

Papaverine, alcohol, and intravenous hypertonic saline solution were not used in this young age group Early ambulation was practiced, the patient usually being allowed out of bed on the fifth day

RESULTS

There was one death, due to pulmonary embolism at the start of an emergency operation for extensive gas gangrene of the thigh. There was loss of the limb in two patients previously described. One leg was gangrenous on arrival, due to a huge expanding hematoma of the distal third of the femoral artery exerting pressure within the cast for a fractured femur, four days after wounding. The second patient developed ischemia from an expanding femoral hematoma for which ligation of the external iliac vessels had been done. Gangrene necessitated mid-thigh amputation ten days later.



Fig 10

Fig 10—Flexion contracture and atrophy of tender right leg two months after wounding. Removal of popliteal arteriovenous aneurysm with tense hematoma and shell fragment underlying the posterior ligament of the knee was followed by uneventful recovery.



Fig 11

Fig 11—Patient (Case 4) two months after emergency quadruple ligation of the right common carotid artery and internal jugular vein. The large arteriovenous aneurysm 18½ inches in diameter ruptured on the ninth day after injury from a mine fragment.

The aneurysms and fistulas were successfully removed in the remaining twenty-six patients without major disturbing sequelae. Seventeen had an uneventful recovery. One patient did fairly well and one extremely well after lumbar sympathectomy for postoperative ischemia following excision of an arteriovenous aneurysm of the distal third of the femoral artery. The first patient had a congested foot and, according to a letter, six months later there was moderate swelling of the lower leg. The second patient made a functionally complete recovery (Case 1).

The remaining six patients had recoveries rated as good in three, fair in two, and slow in two. There was postoperative edema, none severe, in six patients, three following superficial femoral, one popliteal, one posterior tibial, and one axillary ligation. Five of these patients had ligation of both the artery and

vein, one the axillary artery alone. Following the latter, the swelling of the arm receded completely after one month.

Thrombophlebitis developed in two patients. In one, left femoral thrombophlebitis accompanied the extensive gas gangrene of the left thigh and it seemed the probable source of the fatal pulmonary embolus. In the second patient, the phlebitis developed fifty-six days after excision of a ruptured aneurysm of the fourth branch of the profunda femoris artery.

Flexion contracture was severe in three patients. Two had elbows fixed at 90 degree flexion due to expanding hematomas, tense, painful, and swollen for thirty and sixty-four days before intervention. These contractures were extremely difficult to correct postoperatively. The third patient (Fig 10) had the knee fixed at 90 degrees for two and one-half months, due to a tense hematoma and a shell fragment underlying the posterior ligament of the knee, with an overlying popliteal arteriovenous aneurysm. There was gross atrophy of the thigh and calf muscles with exquisite tenderness and pain of the entire lower leg. Removal of the hematoma and shell fragment plus excision of the fistula led to prompt recovery.

Five patients complained of mild to moderate pain in the leg or foot after operation. Three had aching in the calf on walking, one had pain about the inner knee, and one had a slightly painful foot. A sixth patient complained that his foot "goes to sleep."

Of particular interest is the patient who had emergency ligation of the common carotid artery and internal jugular vein (Fig 11).

CASE REPORT

CASE 4—A 19 year old infantryman, riding in a truck which ran over a mine on Omaha Beach, Normandy, France, on Sept 16, 1944, sustained a perforating wound of the neck. The fragment entered the right neck at the thyroid cartilage, and coursed downward and backward to emerge in the right suprascapular area of the neck. Profuse bleeding was controlled by pressure bandage. Huge swelling developed, to form a pulsating mass 18½ inches in diameter. Hoarseness developed the next day. Nine days later, the anterior wound of the neck bled profusely, 2,000 cc of blood were given prior to operation. There was a gaping hole in the wall of the common carotid artery and a similar hole in the internal jugular vein which was separated from the artery by extensive clot. Both were ligated and transfixed with silk and the clot evacuated, 1,500 cc of blood were given additionally. The postoperative course was uneventful, except for frontal headache lasting ten days. There was paralysis of the right vocal cord and numbness and weakness of the right arm.

Two months later, he was still ten pounds underweight and hoarse. He had occasional headaches lasting for two days. The neck scar was well healed. The pulse was 88 and the blood pressure 108/74. The left common carotid pulse was moderately accentuated. There was atrophy of the trapezius muscle, slight weakness of the deltoid, sensory loss over distribution of the radial nerve, but no motor loss. Strength in the right arm was definitely improving.

DISCUSSION

Attention has been directed to the management of the unstable aneurysm and its complications. Four patients with arterial and ten with arteriovenous aneurysms regarded as relatively stable were returned to the Zone of Interior for later operation. There is no question that in the patient with an uncom-

plicated arteriovenous aneurysm, operation should be delayed if possible for two to four months. The shunt markedly reduces the pressure and blood flow through the distal artery. This stimulates the growth of collateral channels (Pemberton and Black⁵), and these should be given every opportunity maximally to develop. Intermittent digital compression may help further.

Arteriovenous aneurysms of smaller vessels distal to the brachial and popliteal vessels may be excised earlier where there is less danger of insufficiency of the collateral circulation.

The rationale for equally long delay in excising the arterial aneurysm is perhaps less clear. Hazardous complications, arising chiefly from expansion and rupture, are more frequent, occurring in 75 per cent of our twenty-three cases. In this lesion, the artery is usually not occluded, the distal blood flow is little altered, and collateral circulation is not stimulated to action. The full arterial force is directed into the arterial aneurysm, increasing the likelihood of interstitial or external rupture. Delay of from four to six weeks would seem desirable, however, to allow subsidence of inflammation, contamination, and infection, to allow intermittent compression of major vessels facing ligation, and to allow an orderly planned operative procedure.

Prompt recognition and treatment of acute and severe complications cannot be emphasized too strongly. Pain should not be severe. If it is unremitting and prominent, it suggests increased tension, interstitial rupture, expansion with pressure upon or infiltration of the regional nerves, and obstructing pressure upon the collateral channels. Once these have developed, the dangers of further delay can be considerable. Keeping the patient under further observation after signs of expansion were present led to serious emergency procedures, postoperative sequelae, and prolonged recovery in several of our patients.

Experiences of other surgeons in this group of hospitals attested to this danger. Kirk²⁹ mentioned rupture of a hematoma of the common femoral artery while under observation, with nearly fatal exsanguination. Seed³⁰ cites three cases of arterial hematomas in which dire complications developed while the patients were under study and preparation for operation. One patient with a hematoma of the external iliac artery died following rupture, despite ligation. The second patient had an expanding hematoma of the femoral artery in which operation was delayed, necessitating eventual amputation. The third patient (Fig 12) had an aneurysm of the left subclavian artery at first small. It steadily enlarged to involve the entire left shoulder and axilla, and paralysis of the radial nerve developed the day before the operation.

Complications such as sensory and motor nerve disturbances, flexion contractures, and atrophy of disuse may be individually evaluated, with preference toward their early rather than late correction. Elkin and Woodhall⁴ emphasized the frequency of combined vascular and nerve injuries in warfare (50 per cent in our forty-three cases). They advised planned excision of the aneurysmal sac and repair of the nerves at the same operation wherever this is possible.

No strong stand is taken for ligation of the vein accompanying a major artery. The rationale of retarding venous flow, thus allowing congestion of the

capillary bed and more complete metabolism of the available blood in the extremity, seems sound. It is felt that until the vitallium tube technique of non-suture bridging of the arterial gap with a vein graft becomes more widely applicable, the majority of American surgeons favor quadruple ligation, that is, ligation of the accompanying vein, even though uninjured.

Attempts have been made whenever feasible to ligate the artery just distal to one of its tributaries. This avoids leaving a blind arterial diverticulum, into the walls of which the force of the arterial beat may be large, dissipated. Ligation in this manner may aid in the development of the relatively small collateral ulnar and geniculate vessels about the elbow and knee.



Fig. 12.—Patient fifty-one days after emergency operation for a ruptured aneurysm of the second part of the axillary artery. The clavicle had been divided for exposure. There is nonunion of the wired clavicle and abduction contracture of the left arm as shown.

The smallest aneurysm should not be overlooked, for it may rupture and quickly cause a major complication. Opportunity to follow patients for an extended period was often provided because of necessary treatment of associated injuries, notably fractures, causing necessary delay in transport.

SUMMARY AND CONCLUSIONS

The immediate rather than late results of our experiences with relatively fresh traumatic aneurysms have been reported. The follow-up study, from one to six months, has not been sufficiently long for final evaluation of the results obtained. Hence, certain observations and statements in summary, rather than conclusions, have been suggested as follows:

1. Nine of the forty-three patients studied had been operated upon in forward hospitals, twenty were operated upon in this general hospital. Fourteen were adjudged relatively stable and safe for the overseas return trip for later operation.

2 The basic lesion of a pulsating hematoma is a partially transected vessel. The completely severed vessel usually does not give rise to a pulsating hematoma.

3 Actual or threatening complications developed in 83 per cent of the arterial and 50 per cent of the arteriovenous aneurysms. The most common were expanding hematomas, with interstitial or external rupture, hemorrhage, and damaging pressure upon both the main and collateral blood supply, and upon adjacent nerves and soft parts.

4 Prompt recognition and treatment of the acute severe complications seemed to lead to improved results. Extended delay once the complication had developed, led in some cases to a serious emergency and in general to a less satisfactory outcome.

5 The incidence of infection was 4.7 per cent, namely, two cases of gas gangrene myositis. One of these proved fatal, resulting in the 3.4 per cent mortality rate among the twenty-nine patients operated upon.

6 There was direct or indirect injury to the nerves in 50 per cent of the cases. Combined repair of the vascular and nerve injuries at the same operation under optimal conditions wherever possible has been advocated.

7 Quadruple ligation with excision of the aneurysm has been the favored procedure since 1886. It was the procedure of choice in this series.

8 Preliminary exposure of the proximal and distal artery and vein was preferred over direct incision into the aneurysm. This allowed an orderly approach, reduced the use of a tourniquet, and aided in avoiding injury to dislocated vessels and nerves.

9 Distorting inflammatory fibrosis or hemorrhagic extravasation was present in all but the very small aneurysms. This complicated the dissection and rendered difficult the use of any procedure for restoring the continuity of the vessel.

10 Loss of blood from deep collateral sources still looms as a prominent feature of the operation, especially for arteriovenous aneurysm.

11 Temporary interruption of the sympathetic nerves with paravertebral blocks, repeated as often as every eight hours, gave real vasodilating benefit, clinically. These should be used in effort to avoid sympathectomy on doubtful indications.

12 If flexion contractures due to expanding hematomas or foreign bodies in the region of joints were allowed to develop, their correction proved difficult and slow postoperatively.

13 Edema was not a serious postoperative problem. It developed in mild form in six patients.

14 The importance of maintaining the blood hemoglobin level at 100 per cent before and after operation is stressed. This aids in providing maximum oxygen-carrying capacity of the blood for the involved limb.

15 Preoperative tests of the collateral circulation were of great help, and they are regarded as an indispensable part of the preparation.

16 The advantages of delay in operating upon the uncomplicated aneurysm are clear. With the arterial aneurysm, the optimum delay would seem to be

four to six weeks. Although the collateral circulation is not stimulated, the interval will favor subsidence of infection and peripheral organization of the hematoma. With the arteriovenous aneurysm, delay of two to four months or more will aid in the maximal development of the collateral circulation.

REFERENCES

- 1 Holman, E. Arteriovenous Aneurysm, Monograph, New York, 1937, The Macmillan Company.
- 2 Holman, E. Immediate and Late Treatment of Arteriovenous Fistula, Australian & New Zealand J Surg 14 75 144, 1944.
- 3 Elkan, D C. Vascular Injuries of Warfare, Ann Surg 120 284-310, 1944.
4. Elkan, D C, and Woodhall, B. Combined Vascular and Nerve Injuries of Warfare, Ann Surg 119 411, 1944.
- 5 Pemberton, J de J, and Black, B M. Surgical Treatment of Acquired Aneurysm and Arteriovenous Fistula of Peripheral Vessels, Review of 67 Cases, Surg, Gynec & Obst 77 462 470, 1943.
- 6 Bigger, I A. Treatment of Traumatic Aneurysms and Arteriovenous Fistulas, Arch Surg 49 170 179, 1944.
- 7 Maybury, B C. Treatment of Arterial Injuries, Brit M Bull 2 142 144, 1944.
- 8 Ogilvie, W H. War Surgery in Africa Brit J Surg 31 313 324, 1944.
- 9 Hunter, W. The History of an Aneurysm of the Aorta, With Some Remarks on Aneurysms in General, Medical Observation and Inquiries 1 323, 1757.
- 10 Bramann, F. Das Arteriovenöse Aneurysma, Arch f klin. Chir 33 1, 1886.
- 11 Matas, Rudolph. Some Experiences and Observations in the Treatment of Arteriovenous Aneurysms by the Intrascapular Method of Suture (Endoaneurysmorrhaphy) With Special Reference to the Transvenous Route, Ann Surg 71 403, 1920.
- 12 Tuffier, M. De l'intubation dans les plaies des grosses arteres, Bull Acad de méd, Paris 74 455-460, 1915.
- 13 Tuffier, M. A propos des plaies des arteres, Bull et mém Soc de chir de Par 43 1469 1471, 1917.
14. Blakemore, A H, Lord, J W, Jr, and Stefkó, P L. The Severed Primary Artery in the War Wounded, SURGERY 12 488 508, 1942.
- 15 Blakemore, A. H, Lord, J W, Jr, and Stefkó, P L. Restoration of Blood Flow in Damaged Arteries. Further Studies on a Non Suture Method of Blood Vessel Anastomosis, Ann Surg 117 481-497, 1943.
- 16 Blakemore, A. H, and Lord, J W, Jr. A Nonsuture Method of Blood Vessel Anastomosis, Experimental and Clinical Study, J A M A 127 685 690, 1945.
- 17 Learmonth, J R. Peripheral Vascular Disorders, Brit M Bull 2 136 138, 1944.
- 18 White, J C. Progress in Surgery of the Autonomic Nervous System, 1940 1942, SURGERY 15 491 517, 1944.
- 19 Gage, M. The Development of the Collateral Circulation in Peripheral Arterial Aneurysms by Sympathetic Block, SURGERY 7 792 795, 1940.
- 20 Veal, J R. The Value of Sympathetic Interruption Following Surgical Repair of Peripheral Aneurysms, M Ann. District of Columbia 9 227 230, 1940.
- 21 Editorial. Arterial Trauma and the Sympathetic, Lancet 2 1944.
- 22 Homans, J. Diseases of the Veins, New England J Med 231 57, 1944.
- 23 Schroeder, C H. The Radiological Demonstration of Traumatic Aneurysm, Arch f klin Chir 204 411, 1943.
- 24 Gnilyorov, T E. One Hundred Thirty Operations on the Blood Vessels, Khirurgiya, 40 55, 1942.
- 25 Kilhan, H. Ueber die Indikation zur Frühoperation von Gefaessverletzungen und Aneurysmen, Arch f klin Chir 204 355 410, 1943.
- 26 Reid, M R. The Effect of Arteriovenous Fistula Upon the Heart and Blood Vessels, Johns Hopkins Hosp Bull. 31 43, 1920.
- 27 Davis, Allan. Personal communication.
- 28 Homans, J, Allen, A. W, Elkin, D C, De Takats, G, and Maddock, W G. Burns, Shock, Wound Healing and Vascular Injuries, Military Surgical Manual, 205, 209, 1943.
- 29 Kirk, G D. Personal communication.
- 30 Seed, L. Personal communication.

A CASE OF COSTOCLAVICULAR COMPRESSION OF THE SUBCLAVIAN ARTERY SIMULATING ARTERIAL ANEURYSM

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CONSIDERABLE attention has been directed in recent years to a group of clinical syndromes in which certain vascular and neurologic symptoms in the upper extremity may result from structural abnormalities or may be associated with positional changes. The clinical picture associated with cervical ribs or with tendinous or cartilaginous bands extending from rudimentary cervical ribs or transverse processes, and the scalenus anticus syndrome, have become well-recognized entities. More recently, symptoms resulting from compression of the subclavian vessels and brachial plexus between the first rib and clavicle have been described,¹ as well as the relatively normal obliteration of pulsation in the arteries of the upper extremity in various positions of hyperabduction, resulting in neurovascular complaints in those who by habit or work maintain such positions for relatively long periods of time.² It is the purpose of this communication to describe the findings in a patient in whom compression of the subclavian artery between the clavicle and the first rib led not to any subjective complaints but presented a picture which simulated that of arterial aneurysm.

CASE REPORT

The patient was a soldier, 30 years of age, who was admitted to Mayo General Hospital on Oct. 24, 1944. Prior to Aug. 2, 1944, he had enjoyed good health and had had no vascular complaints. On this date he was wounded in France by shell fragments, receiving penetrating soft tissue wounds in the left parietal region of the scalp and in the left trapezius area. There was little bleeding. The wounds were debrided in an evacuation hospital and on August 5 he was admitted to a general hospital where an abnormal pulsation and bruit were noted in the left infraclavicular region. A diagnosis of arteriovenous aneurysm was made and the patient was transferred to the Zone of the Interior and to the Vascular Center at Mayo General Hospital.

The wounds had been secondarily sutured on August 15, with good healing. He had no complaints referable to the left upper extremity. He had noted no numbness, paralysis, or pain, and had observed no color, temperature, or sweating changes. He had noticed no dilated veins, no edema and no trophic lesions. He thought he had noted some little swelling in the left clavicular area.

Examination revealed no visible mass or abnormal pulsation. There was, however, a strong pulsation palpable just beneath the mid portion of the left clavicle not present on the contralateral side, and here a loud systolic bruit was heard. No thrill was palpable. He had well-developed muscles in both shoulders and arms. It was impossible to compress the subclavian artery above the clavicle nor the axillary artery beneath it, and hence tests for collateral circulation could not be carried out. There were no color changes in hands or feet. There was no thickening or tortuosity of the peripheral arteries. Radial, ulnar, and brachial

pulses were normal and equal in the two extremities. Venous filling time was three seconds in both hands. A number of dilated veins were noted in the left pectoral and infraclavicular area. Skin temperature studies revealed no significant difference in the temperature of the fingers of the two hands. There was no edema, no abnormal sweating, no trophic or neurological changes. Kahn reaction was negative. Roentgenograms revealed several metallic fragments in the left parietal scalp, in the left side of the neck, and in the left supraclavicular area.

It was felt that the patient had an arterial aneurysm, traumatic in origin, of the distal end of the left subclavian or of the proximal end of the axillary artery. Because of the inability to test the collateral circulation and a feeling of insecurity as to its adequacy, it was thought that it would be safer to carry out a sympathectomy before exploration. On Oct. 31, 1944, a preganglionic upper dorsal sympathetic denervation was accomplished. On December 30 the vessels were explored. The entire extent of the axillary artery was visualized by dividing the insertions of the pectoralis major and minor muscles. No aneurysm was found in the axillary artery nor in any of its branches. The axillary vein was bifid and was somewhat dilated just distal to the point where it passed beneath the clavicle and where its two branches joined. The clavicle could be elevated sufficiently to permit visualization and digital exploration of the subclavian vessels beneath, and neither here nor above the clavicle was there evidence of aneurysm nor of constriction of the vessel by scar tissue. No foreign body was encountered. No bruit was audible at the close of the procedure. The muscles were resutured and the wound was closed in layers with fine black silk sutures. Convalescence was uneventful.

It was noted postoperatively that the bruit was sometimes loudly audible and sometimes absent. The prominent pulsation beneath the clavicle persisted. Finally, observations were made which it is felt offer adequate explanation for the findings. The bruit was present and intense when the patient stood with shoulders unsupported. It was absent when he lay down. When he sat with elbows resting on the arms of a chair a single short bruit was heard with each inspiration and expiration but was not audible when respiration was held either in inspiration or expiration. When he stood or sat with arms unsupported hanging by his sides the bruit ceased completely during full inspiration, and concomitantly all arterial pulsations in the left upper extremity disappeared. Downward traction upon the shoulders had no effect upon pulsation, bruit, or the radial pulse, nor did various positions of abduction or hyperabduction with the extremity in the plane of the body, forward or backward. Similarly, strong backward thrusting of the shoulders with head turned to either side had no effect upon bruit, pulsation, or radial pulse. When he attempted to elevate the left shoulder against downward traction on the arm the bruit often disappeared. Blood pressure was 128/78 in the right arm 120/80 in the left. As shown in Table I, oscillography was normal in the two arms except during deep inspiration with the patient sitting and arms hanging unsupported by his sides when oscillations ceased completely in the left arm. The

TABLE I. SHOWING OSCILLOMETRY IN THE TWO ARMS WITH VARIOUS POSITIONS OF THE UPPER EXTREMITIES DURING NORMAL BREATHING AND DURING DEEP INSPIRATION

POSITION OF EXTREMITY	OSCILLOMETRY			
	RIGHT		LEFT	
	NORMAL BREATHING	DURING DEEP INSPIRATION	NORMAL BREATHING	DURING DEEP INSPIRATION
Arm hanging down adducted to side	6 at 110	6 at 110	7 at 110	0
Arm hanging down, shoulder thrust backward, head turned to opposite side	6 at 110	6 at 110	5.5 at 110	0
Arm abducted 90 degrees	6 at 110	6 at 110	6 at 110	0
Arm hyperabducted over head	5 at 110	5 at 110	6 at 110	0

same occurred when the patient stood with arms hanging without support. When the patient lay down there was no change in oscillometry during forced inspiration. Venous pressures in the cephalic veins in the antecubital fossae with the patient standing varied from 48 to 60 cm in both arms. With deep inspiration there was a rise of 5 cm or more on the left side and a drop of about 5 cm on the right.

The left hand remained somewhat better colored than the right in all positions. Radial and ulnar pulses were full in both wrists. In a room at 22° C the skin temperatures of the right fingers varied from 17.5 to 20° C, those of the left from 32.5 to 33.5° C. The left side of the face and the left upper extremity did not perspire. Ergometer studies done on several occasions revealed no essential difference in fatigability of the right and left hands. The patient had a full range of shoulder motion in the left shoulder and had no complaints referable to the upper extremities. X rays taken in the lordotic position showed some narrowing of the space between clavicle and first rib on the left with inspiration but these findings were not conclusive.

The final impression held was that the patient's signs were due to compression of the subclavian vessels between the first rib and the clavicle. When he stood with arms unsupported there was partial compression giving a loud systolic bruit. In the recumbent position this was absent. Full inspiration in the standing or sitting position caused sufficient compression to shut off completely all flow of blood to the left upper extremity. With normal respiration this did not occur. Since the patient had no complaints and had ample circulation under ordinary conditions it was felt that operative interference was unjustified. The patient was returned to duty.

DISCUSSION

The diagnosis of arterial aneurysm is ordinarily not difficult. The three cardinal signs, a pulsating mass, systolic bruit, and systolic thrill, are often present. Not infrequently, particularly if the aneurysm is covered by heavy musculature, a definite pulsating mass is not visible or palpable but there is almost always an abnormally strong pulsation in the involved area. The thrill is often absent. The bruit varies in intensity and its intensity gives no clue as to the size of the aneurysm. Occasionally the diagnosis is difficult, especially when the aneurysm is deep to well-developed muscles. The most common conditions which may be confused with aneurysm are solid tumors which lie beneath or upon large arteries with resultant transmitted pulsation and with a bruit from partial compression, and conditions of partial constriction of arteries by scar tissue associated with a systolic bruit. Rarely scalenus anticus compression and cervical ribs may cause signs simulating aneurysm and may indeed be associated with aneurysmal dilatation of the artery.

In those instances of costoclavicular compression reported by Falconer and Weddell no signs are described which would have made one suspicious of aneurysm. In one of the four cases they described, the subclavian artery was slightly dilated proximal to the point where it passes underneath the clavicle. Because of this occurrence they suggested that the distal artery dilatation observed in certain cases of cervical rib may actually have been unassociated with cervical rib pressure but may have resulted from a coincident costoclavicular compression. In those cases of cervical rib and scalenus anticus syndrome in which there are signs suggesting aneurysm or in which arterial dilatation is noted at operation, attention to the disorder ordinarily results from the neurovascular complaints in the extremity.

In the cases of costoclavicular compression reported by Falconer and Weddell, backward and downward movement of the shoulder caused the greatest

compression of the subclavian vessels, and hyperextension of the neck did this to a lesser extent. No mention is made of the effect of respiratory movements. It is of interest that in the case I have described deep inspiration completely occluded the subclavian arterial blood flow. There was evidence of partial compression of this vessel as manifested by a systolic bruit when the patient stood or sat with his arm hanging down unsupported. Backward and downward movements of the shoulder and hyperextension of the neck seemed to have little further demonstrable effect. In cases of costoclavicular compression observed in the future with the vascular or neurologic complaints described by Falconer and Weddell it will be of interest to observe whether there is present any abnormal pulsation, systolic bruit, and whether the pulses in the arm are obliterated by deep inspiration.

The case I am reporting represents, as far as I am aware, a new type of syndrome simulating aneurysm. The patient had no complaints at all. Because of a wound which might have injured the subclavian or axillary artery and signs suggestive of aneurysm he was thought to have an asymptomatic traumatic arterial aneurysm. Prior to operation no doubt existed as to the validity of the diagnosis. Aneurysms in this area as large as lemons, have, in my experience, not infrequently been accompanied by less convincing signs, such as no pulsating mass, no thrill, less strong pulsation, and less intense bruit. So strong was the impression that the patient had an arterial aneurysm that he was subjected to two operations. No aneurysm can be explored without the definite possibility that its cure may entail ligation of the artery involved. Although the subclavian and axillary arteries can often be severed with relative impunity this is not necessarily true. I have recently seen a patient operated upon elsewhere for such an aneurysm, in whom gangrene and loss of the thumb resulted. Arterial aneurysms, in contrast to arteriovenous aneurysms, provide notoriously poor stimulus for development of collateral circulation. The efficacy of sympathectomy in improving a functionally insufficient collateral circulation is well established. For these reasons the patient was sympathectomized prior to exploration. Had the proper diagnosis been made before operation the patient might have been spared these operative procedures. It is in the hope that recognition of the syndrome described, rare though it may be, may be useful in this regard that this case is reported. The question can be raised as to whether the clinical picture was the same before and after operation. It can only be said that nothing was done at exploration which should have altered the situation and that the postoperative findings offer adequate explanation of the picture presented before operation.

SUMMARY

A case of costoclavicular compression of the subclavian artery is presented and discussed which closely simulated that of arterial aneurysm.

REFERENCES

- 1 Falconer, M. A., and Weddell, G. Costoclavicular Compression of the Subclavian Artery and Vein, *Lancet* 245: 539-543, 1943.
- 2 Wright, I. S. The Neurovascular Syndrome Produced by Hyperabduction of the Arms, *Am Heart J* 29: 119, 1945.

BATTLE CASUALTIES FROM THE PHILIPPINE ISLANDS

SUMMARY OF EXPERIENCE WITH FOUR THOUSAND AND FORTY CASES

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THE surgical management of battle casualties has been divided appropriately by Churchill into initial surgery, reparative surgery, and reconstructive surgery

This presentation is an analysis of surgical battle casualties admitted to this general hospital in Hollandia, Dutch New Guinea, from the campaign for the Philippine Islands in World War II. During a period of five months, 4,040 surgical battle casualties (wounded in action) were hospitalized. During the first six weeks of the campaign, patients were transported to this hospital via hospital ships, arriving five to ten days after injury. As the battle lines extended to the Northern Philippine Islands, the time interval between injury and admission to this hospital increased. Evacuation of patients in these latter months necessitated emergency treatment at a battalion aid station or clearing company, an ambulance ride of varying numbers of miles, treatment at an evacuation hospital, and transfer to a landing craft and to one or more hospital ships over a period of time averaging twenty-one days. Supply and evacuation lines, which in the Southwest Pacific extended over island chains and long water routes, created a military situation in which medical installations of all echelons were called upon for the ultimate in surgical care. Data presented in this analysis represent a tribute to the excellent relay management of patient care by medical units in the forward areas and by the medical and nursing staffs of hospital ships. Although many of the wounded were evacuated from the Philippines by air to general hospitals, the patients reported upon in this analysis all were transported via hospital ship. Since the campaign for the Philippine Islands was the first large scale amphibious operation in the Southwest Pacific, it afforded the opportunity to study the effects of hard learned lessons in military medical practice. To one of us who had cared for battle casualties from the jungle fighting in New Guinea, on New Britain, and on the Admiralty Islands in the earlier years of the war, it was apparent that the improved condition of the patients and of their wounds was due to several innovations in military medical methods. One of these was ready availability of whole blood at the time of beach landings. This was supplied by landing craft equipped with refrigerated blood banks. Surgical teams, the personnel of which were recruited from the best surgical specialist talent in this theater of war, functioned in the forward area, often in the front lines. The fact that surgical consultants, vested with authority to define the treatment of the casualties, assumed the role of instructors, constantly advising, consulting, and teaching, was a factor of inestimable value. Because of

their relative adaptability to the rigors of life in a fox hole, younger medical graduates often were assigned to the medical installations in the forward areas. While these officers were suited better than older surgeons to the life under battle conditions, it was not always true that their knowledge of surgical principles and procedures was sufficient to meet the demands of early surgical care of casualties. It was the excellence of the professional activities of these young officers which rewarded the efforts of the surgical consultants during the campaign for the Philippine Islands. The wounded arrived at general hospitals in better condition than did those of earlier campaigns. A factor which contributed to this result was that the transportation of wounded soldiers by hospital ships, staffed with selected professional personnel and equipped with all necessary facilities, represented a step in continuation of treatment rather than an interruption to it. The professional personnel of the forward areas and of the hospital ships may view with satisfaction the facts that 43 per cent of patients received adequate dosages of penicillin while en route to this hospital, that 71 per cent of patients requiring surgery received their initial operative surgery within eight hours after injury, and that only forty-six patients (approximately 1 per cent) developed serious anaerobic infection or gas gangrene.

In the continuation of surgical management of casualties the reparative phase of surgery is carried out in the general hospital. With adequate facilities and personnel the opportunity is presented here to start the patient on the road to recovery. Causes of fever are determined, anemia is combated by frequent transfusions of blood, tropical diseases are diagnosed and treated, infected wounds are given wide drainage, fractures are reduced, granulating wounds are closed by secondary suture or skin grafting, complications are managed, and physical therapy is started. Thus, in the Southwest Pacific Theater of War, due to the circumstance of distance and the strategic locations of general hospitals, the reparative phase of surgery has had an opportunity for development which has been unequaled in this world conflict. It is true that as the surplus of empty hospital beds diminished, there was pressure to evacuate patients promptly to the Zone of the Interior. But the decision as to whether any patient was in condition to be transported over the long water route to the United States rested finally with the professional staff of the general hospital. Thus, it was the policy to hold major fractures until their fragments were united solidly, to close all wounds by secondary suture or skin grafting, to remove foreign bodies, to manage the late treatment of gunshot wounds of the head, to repair injuries of peripheral nerves, to treat hemothorax vigorously until full expansion of the lung was effected, to reduce complicated fractures of the jaws and facial bones, to maintain traction effectively to amputation stumps, to treat the secondary complications of peripheral vascular injury, and to initiate the first steps in the physical and mental rehabilitation of the wounded. Here again the far-reaching influence of the professional consultants of the Army Service Forces was evidenced in the accurate selection of professional personnel to fit the needs in surgery and the surgical specialties in these large general hospitals which often housed as many as 3,000 patients at one time.

Of the 4,040 surgical battle casualties which were admitted to this hospital from the campaign for the Philippine Islands, exact statistical data are available on 3,383 patients. The information in this analysis was gleaned from a personal study of the patients and their disabilities by a medical officer as they arrived at, and underwent treatment in, this general hospital. The report is arranged similar to the fashion of beside analysis. Anatomic locations of injuries are considered first. Then, in order, complications, treatment before arrival at this hospital, the time interval between injury and operative surgical treatment, the elapse of time between injury and arrival at this hospital, the condition of the patients on admission, the mortality rate, and the causes of death will be discussed.

TABLE I WOUNDS OF SOFT TISSUE IN ANALYSIS OF 3,383 BATTLE CASUALTIES

ANATOMIC LOCATION	NUMBER OF WOUNDS	PER CENT OF TOTAL
Scalp	105	3.3
Face and neck	222	7.0
Thoracic wall	284	9.1
Abdomen	124	3.9
Buttock	161	5.1
Shoulder	234	7.5
Upper extremity	662	21.2
Lower extremity	1,045	33.5
Multiple minor wounds	168	5.3
Burns	59	1.8
Blast symptoms	55	1.7
Total	3,119	

In Table I are listed the locations of wounds of soft tissue. The high incidence of wounds of soft tissue (71 per cent of all wounds) compared to the relatively low incidence of fractures (29 per cent of all wounds) in this war against the Japanese supports the impression that the explosive missiles (mortar shells, artillery shells, and bombs) of the enemy commonly fragment into many small particles. Not many patients were seen who were struck by very large fragments of shells. Probably in some cases larger fragments of shells were removed from patients at medical installations in the forward areas. Many reports, however, are in agreement that larger shell fragments were not encountered as often as were multiple smaller ones and that the impact of these larger missiles usually caused death. Commonly these small missiles caused great damage to soft tissues or bones although the wounds of entry and of exit were relatively small. The largest foreign body removed from the group of patients at this hospital was a fragment of hand grenade which measured 2 by 4 cm. The historical pattern of war wounds is followed in this series of cases in that the extremities were involved in 62 per cent of the cases. Forty of the fifty-nine cases of burn were flash burns sustained on the decks of Liberty ships which were crash-dived while in harbor.

It is interesting to note that wounds of soft tissue occurred almost two and one-half times as often as compound fractures. Thus, the importance of the surgery of wounds of soft tissue is emphasized. It is one of the most important aspects of reparative surgery.¹ Approximately one-third of the procedures in operative surgery in this hospital were directed toward the closure, the revision,

or the skin grafting of wounds of soft tissue. It is believed that the surgeon who emphasizes the prompt surgical repair of wounds of soft tissue will accomplish more by returning soldiers to duty and by preventing ultimate deformity than will the surgeon whose efforts are limited to the care of the more grave injuries of the osseous, vascular, nervous, or other systems.

TABLE II. FRACTURES IN ANALYSIS OF 3,383 BATTLE CASUALTIES

ANATOMIC LOCATION	NUMBER OF CASES	PER CENT
Skull	62	4.9
Facial bones including mastoid	47	3.7
Mandible	89	7.1
Spine	29	2.3
Ribs	80	6.3
Pelvis	30	2.4
Shoulder girdle	57	4.5
Humerus	122	9.7
Forearm bones	111	8.7
Bones of wrist and hand	106	8.4
Femur	143	11.2
Patella	12	1
Tibia and/or fibula	174	13.7
Bones of ankle and foot	123	9.7
Wounds of knee joint	47	3.7
Wounds of elbow joint	20	1.6
Total	1,272	

As shown in Table II, fractures of the femur (11.2 per cent of all fractures) are not significantly more frequent in occurrence than are fractures of the bones of the face (10.8 per cent of all fractures). Fractures of the skull, on the other hand, account for less than 5 per cent of the major fractures. This is mute evidence of the particular value of the metal helmet in the Pacific war in which the enemy up until this time has used small bullets and shells which fragment into small particles. In the Luzon campaign more heavy artillery was employed and the incidence of fractures of major bones was greater than in the earlier fighting in the Philippines.

TABLE III. AMPUTATIONS IN ANALYSIS OF 3,383 BATTLE CASUALTIES

TYPE	NUMBER OF CASES
Disarticulation, shoulder	1
Arm	18
Forearm	4
Segments of hand	36
Thigh	25
Leg	20
Segments of foot	8
Total	112

In warfare the incidence of major amputations is of prime interest. Excluding the partial amputations of the hands and feet only sixty-eight or 2 per cent of battle casualties had been subjected to major amputations. It is reasonable to conclude that all patients who survived major amputations were admitted eventually to a general hospital. There were only three cases in which the amputees had lost both limbs. One of these had lost an arm and the opposite leg, the other had lost both arms, the third had lost both legs. Forward installa-

tions regularly performed the guillotine type of amputation at the lowest possible level and traction to the skin had been applied to the amputation stumps in preparation for transportation in all but ten of the patients. As a result, at the time of arrival at this hospital, the wounds showed healthy granulation tissue with the skin of the stump drawn down over the level at which bone and muscle had been incised. In the management of these wounds of amputation stumps, it was apparent that the cicatricial effect of long-standing granulation tissue worked synergistically with external traction on the skin to reduce the open wound to a minimum in a period of four to six weeks. Contrary to the principles of surgery of simple wounds of soft tissue, there was no indication for procedures of secondary suture or skin grafting. These patients were given intensive physical therapy to the muscles of the stump and attention was directed toward the psychologic adjustment of the patient to his newly acquired deformity. Many patients who had lost an arm or hand had learned to accomplish tasks such as writing and shaving at the time of their evacuation from this hospital. Revision of amputation stumps is a responsibility of the centers for reconstructive surgery in the United States.

Included in Table IV are the injuries of all organs or structures other than skin, muscle, and bone. These made up 23 per cent of the total number of cases. Comparing Tables II and IV it is noted that forty-seven or more than two-thirds of the sixty-two patients with skull fractures had evidence of associated injury to the brain. In twenty-seven of these, intracranial abscess had developed as a result of gunshot wound. In all of these the abscess was centered about the indriven fragments of skull. Often the missile had lodged at a distant site in the brain or had made its exit from the skull. The late treatment of war

TABLE IV VISCERAL INJURIES IN ANALYSIS OF 3,383 BATTLE CASUALTIES

ORGAN INVOLVED	NUMBER OF CASES
Brain	47
Spinal cord	40
Peripheral nerve	149
Eye (foreign body, contusion, laceration)	92
Ear (symptoms of blast with perforation of tympanic membrane)	149
Pharynx	8
Thyroid	3
Lung	167
Wound of the chest and abdomen	9
Penetrating wounds of the abdomen (no injury to viscera)	30
Perforation of the stomach	5
Perforation of the small bowel	7
Perforation of the colon	26
Liver	10
Spleen	1
Kidney	10
Ureter	1
Bladder	12
Testis	5
Penis	7
Scrotum	7
Spermatic cord	1
Urethra	4
Total	790

wounds of the head will be discussed in another publication.² Of the twenty-one patients with paraplegia due to injury to the spinal cord, fifteen were treated by laminectomy. The operative procedure had been carried out on ten of these in hospitals in the forward areas. Neurologic examination and x-ray findings showed that laminectomy offered hope of improvement in only five patients during hospitalization here. Following operation two of these recovered completely from paralysis and in three there was definite improvement. There were 149 cases of injury to peripheral nerves. Forty-nine of these were in association with fractures. In forty-five cases neurolysis or nerve suture was performed and in twelve others reparative surgery of nerves was done at the time of operation for peripheral aneurysm. In fifty-five cases the patients were evacuated to the United States, their wounds having healed spontaneously or by secondary suture or skin grafting. There were only two patients in this entire series in whom both eyes had been enucleated. One of these patients succumbed to meningitis secondary to persistent rhinorrhea. The cases of blast were those in which the symptoms of tinnitus, headache, or vertigo were associated with objective evidence of blast injury such as perforation of the tympanic membrane. One wound of the thyroid was interesting and bears reporting. The soldier was hit in the right cheek by a .30 caliber bullet which took out the maxillary teeth and passed through the lower margin of the mandible. Then, turning butt end downward, the bullet passed down into the neck where it gave him only moderate discomfort. At operation it was found completely buried in the upper pole of the left lobe of the thyroid.

There were two cases in which wounds of the kidney presented the indication for nephrectomy. One of these was of interest in that previous operation had been performed aboard ship. Hemorrhage from a large perforating wound of the lower pole of the kidney had been controlled by packing. Secondary hemorrhage while in this hospital necessitated operative intervention. The missile had destroyed the central substance of the lower pole. In addition, there was a vertical fracture of the upper pole so that nephrectomy rather than heminephrectomy was necessary. Another case of injury to the urologic tract is of interest. This patient had been wounded by a .25 caliber rifle bullet which entered the left buttock. While voiding, the patient noted that the stream of urine suddenly stopped. He was able to palpate an object in the perineal region and succeeded in voiding the .25 caliber bullet. Orchidectomy was necessary in four of the five cases of injury to the testicle. Wounds of the penis were minor in three cases, while in one case extensive deformity had been caused by cicatricial replacement of the corpus spongiosum. Reparative surgery by means of plastic flaps was successful in all cases.

Table V gives a fair insight into the operation of a surgical service in a general hospital in the Communications Zone. In 341 cases there were major complications as listed here. Minor complications of wounds and the problems associated with intercurrent tropical diseases are not included. Analysis of the cases of infection and gangrene due to *Clostridium welchii* will be set forth in

TABLE V COMPLICATIONS IN ANALYSIS OF 3,383 BATTLE CASUALTIES

LOCATION	NUMBER OF CASES
Brain abscess	15
Epidural abscess	10
Fungus cerebri	3
Pneumocephalus	1
Rhinorrhea	2
Paralysis due to cerebral injury	25
Paralysis due to injury to spinal cord	21
Hemothorax	79
Hemothorax (fibrinous)	7
Pneumothorax	6
Tension pneumothorax	1
Empyema	49
Bronchopleural fistula	3
Subphrenic abscess	5
Paralysis of recurrent laryngeal nerve	5
Peritonitis	1
Fecal fistula (colostomy)	14
Fecal fistula (rectum and buttock)	8
Urinary fistula	13
Bladder	7
Ureter	2
Urethra	4
Infections and gangrene due to <i>Clostridium welchii</i>	31
Pyroarthrosis of knee	14
Volkman's contracture	1
Vascular complications	27
False aneurysms	6
Pulsating hematoma	4
Arteriovenous fistulas	10
Laceration of artery peripheral	4
circulatory gangrene	
Aneurysmal varix (common iliac vessels)	1
Secondary hemorrhage from arterial tear	2
Total	341

detail in a subsequent communication.³ It is interesting to note that this complication occurred in only 11 per cent of all cases and in 36 per cent of the 1,272 cases of fracture.

Intrathoracic complications occurred in 144 or 80.6 per cent of the 167 cases in which the missile had transversed the lung or mediastinum. In seventy-nine cases the complication of hemothorax was handled competently by frequent thoracentesis during the early weeks after injury. Fibrinous hemothorax developed in only seven cases. Pneumothorax was present in only three patients and these were cured by repeated aspiration. In one case tension pneumothorax was managed successfully by aspiration without resorting to water-seal or flutter-valve decompression. Analysis of the forty-nine cases in which empyema had developed is of interest. None of these patients were admitted to this hospital until the fourth to the seventh week following injury. In the early days after injury these patients were transferred to several hospitals and three ships, and thoracentesis had not been done regularly. Roentgenograms showed complete collapse of the lung and aspiration yielded thick pus. The fact that in the majority of cases the causative organism was not recovered on culture was attributed to the intrathoracic injection of penicillin. Sixteen of these patients responded to repeated aspiration and injection of penicillin.

Sixteen were treated by closed aspiration drainage and seventeen by thoracotomy. The late treatment of cerebral complications due to gunshot wounds of the head² and also the management of pulsating hematoma, false aneurysm, and arteriovenous fistula⁴ will be reported upon in detail in subsequent communications.

After consideration of the types of injury and their complications, interest centered in the treatment before arrival at this hospital. As is shown in Tables VI and VII, an amazingly high percentage of casualties received the benefit of therapy with penicillin or sulfonamide drugs or both. The condition of these patients on arrival and the records of their treatment in the forward areas reflect the greatest credit on the work of the forward echelons of the Medical Department of the Army.

TABLE VI. TREATMENT BEFORE ARRIVAL AT GENERAL HOSPITAL IN ANALYSIS OF 3,383 BATTLE CASUALTIES

PATIENT RECEIVED	NUMBER OF PATIENTS	PER CENT
Adequate sulfonamides	2,849	84.0
Penicillin	1,479	43.0
Gas gangrene antitoxin	174	5
Operative surgical treatment	2,502	73.6

Seventy-three per cent of all patients had required operative surgery. Sulfanilamide and penicillin had been started at the time of first surgical treatment and had been continued until the patients were admitted to this hospital or until the clinical course indicated its discontinuance. Undoubtedly this vigorous therapy as an adjunct to surgery was rewarded by a lowered mortality rate. However, it was the united opinion of surgeons who treated these war wounds that the intramuscular injection of penicillin did not in itself produce healthy granulation tissue. Wounds of patients who had been treated with penicillin showed no outstanding difference from those in patients not so treated. The health of the wound was a direct reflection of the adequacy of the local surgical treatment. The conclusion follows that surface infection of wounds still is a problem for treatment by débridement and surgical dressings. None of the wounds had been treated locally with penicillin prior to arrival at this hospital. The low number of cases in which gas gangrene antitoxin was used is an indication of the lack of confidence exhibited by surgeons generally in the use of this agent. In the clinical management of cases of infection or gangrene due to *C. welchii* there was no convincing evidence that the antitoxin is of value.

TABLE VII. TIME INTERVAL BETWEEN INJURY AND OPERATIVE SURGICAL TREATMENT IN ANALYSIS OF 3,383 BATTLE CASUALTIES

TIME OPERATED UPON	NUMBER OF CASES	PER CENT
Under 8 hours	1,781	71.1
Under 12 hours	245	9.7
Under 24 hours	268	10.7
Under 48 hours	141	5.6
Over 48 hours	67	2.6
Total	2,502	

Moreover, it was found that penicillin was not of value in combating the toxemia or the sepsis in such cases. These points will be discussed in a separate publication.³

Attention is called to the great difficulty experienced in evacuating the wounded at night because of the Japanese night infiltration tactics. Despite the difficulties of amphibious operations and the problems in jungle fighting, 71 per cent of those patients requiring operative surgery were operated upon under eight hours. This efficiency in evacuation of wounded and in the availability of equipment and personnel for the early treatment of casualties in the forward areas will go down in the history of the Army Medical Corps as one of its glorious achievements. The necessity for the performance of débridement in that golden period before a contaminated wound is converted into an infected one was demonstrated in World War I. In this conflict the patients also had the advantage of oral sulfonamide therapy from the time of injury until the time of operation.

Of interest also is the time interval between injury and arrival at this general hospital. As previously stated, the casualties included in this analysis arrived fairly soon after injury during the first six weeks of the period reported upon. During this time the fighting was on Leyte and Samar Islands and 1,112 or 33 per cent of the group of 3,383 casualties arrived on the fifth to the tenth day after injury. The remainder arrived from eleven to fifty-five days after injury as the battles took place in Luzon and related islands in the northern Philippines.

After determination of what had happened to these patients in the forward areas, interest centered on their condition on admission to this hospital. Of the 3,383 patients, 219 were critically ill. Two patients were moribund on arrival and both died shortly after admission. Three hundred ten patients had fever with elevation of temperature over 101° F. Plaster casts in 318, approximately 25 per cent of the fracture cases, were malodorous, stained, or broken. Two hundred forty-four or 7 per cent of all cases had secondary anemia, the red blood cell count being 3,000,000, or lower. Excluding fractures of the mandible which will be discussed in detail in another publication, there were sixty-three cases in which the fracture had been immobilized improperly. These made up 5 per cent of the fracture cases. "Tobruk" splints had been applied in ten cases. All of these showed severe edema of the ankle. Two developed anaerobic cellulitis. Velpeau bandages reinforced with plaster had caused pressure necrosis over the dorsum of the hand or forearm in three cases of fracture of the humerus. Apparently this type of dressing was favored by some medical officers who were conscious of the difficulties of transporting patients wearing abduction shoulder spicas.

There were nine deaths in this series of 4,040 consecutive battle casualties. This fixes the case mortality rate at $\frac{1}{4}$ of 1 per cent. The condition of the patients at the time of embarkation for the United States from this post was such that it is unlikely that any of them failed to survive. The causes of death are as follows: meningitis secondary to cerebral abscess, two cases, gas gangrene,

three cases, peritonitis and gangrene of abdominal wall, one case, pulmonary embolus arising from femoral arteriovenous fistula, one case, hemorrhage from aneurysmal varix of the common iliac veins, one case, purulent pericarditis and septicemia following drainage of subphrenic abscess, one case

SUMMARY

Report is made on experiences with 4,040 surgical battle casualties from the campaign for the Philippine Islands. Detailed analysis of 3,383 of these cases is presented. These were patients who were admitted to a general hospital in Dutch New Guinea. Data are presented concerning the types of injury, the complications, the treatment given in the forward areas, the time interval between injury and operative treatment, the elapse of time between injury and admission to this hospital, the condition of the patients on arrival, the mortality rate, and the causes of deaths. Wounds of soft tissue occurred two and one-half times as frequently as did major fractures. The majority of wounds were caused by small caliber bullets or small fragments of shells or bombs. Minor wounds of entry and exit commonly marked the site of extensive damage to underlying soft tissues and bone. Major amputations had been performed in only 2 per cent of cases. Eighty-four per cent of patients had received sulfonamide therapy from the time of injury until admission to this hospital. Forty-three per cent of patients had received intramuscular penicillin in adequate clinical dosage while en route to this base. Undoubtedly the fact that this high percentage of the wounded were treated by sulfonamide drugs or penicillin as an adjunct to surgery has been reflected in the saving of many lives. Close observation of wounds has provided no evidence that such therapy has resulted in less extensive infection of serious wounds. Cases of hemothorax which had been treated by thoracentesis at regular intervals did not develop complications whereas those which had not been so treated were complicated further by the development of fibrinous hemothorax or empyema. Infections or gangrene due to *Cl. welchii* occurred in 11 per cent of all cases and in 3.6 per cent of all fractures. Thirteen of these battle casualties died in this hospital. The case mortality rate at this station therefore is $\frac{1}{3}$ of 1 per cent.

The introduction of certain military medical methods in this theater has resulted in improved condition of patients and of their wounds on arrival at a general hospital. Innovations in military medical practice during this campaign included availability of whole blood in the forward areas, the assignment to the forward areas of surgical teams comprising the best available professional talent, and the organized efforts of the surgical consultants who advised, demonstrated, and taught in the forward areas. The distances involved in the Southwest Pacific during the campaign for the Philippine Islands necessitated a relatively prolonged period for the patients on the hospital ships. Many patients were evacuated to general hospitals by air but this hospital received only those patients who were brought by ship. The strategic location of general hospitals at points far distant from the United States during this campaign afforded an unequalled opportunity for the application of the principles of reparative surgery.

This analysis of battle casualties reflects the greatest credit upon the work of the medical installations in the forward areas for, in the campaign for the Philippine Islands, emphasis was placed on getting the surgeon to the patient as well as upon the prompt evacuation of the wounded

The subjects of aneurysm, gunshot wounds of the head, infections and gangrene due to *Cl welchii*, secondary suture, and skin grafting will be presented in subsequent publications which are in preparation at this time ¹⁻⁴

REFERENCES

- 1 Conway, Herbert, and Coldwater, Kenneth B Principles in Reparative Plastic Surgery, SURGERY 19 437, 1946
- 2 Conway, Herbert, and Hendricks, Robert T The Late Definitive Treatment of Gunshot Wounds of the Head, SURGERY (In press)
- 3 Conway, Herbert Anaerobic Infection and Gangrene of War Wounds in Casualties From the Philippine Islands, SURGERY 19 553, 1946
- 4 Conway, Herbert, and Plam, George Pulsating Hematoma, False Aneurysm, and Arteriovenous Fistula Due to War Injuries, SURGERY 19 383, 1946

AIR BLAST EFFECT IN A CAVE

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IT IS not definitely known how effective a role an blast plays in the neutralization of enemy cave emplacements when relatively small charges of high explosives are used. Although death of personnel in caves usually results from the primary air blast it is not possible to relate the charge to its effectiveness since data on the blast effects of explosives detonated in closed spaces are not available. Bernal¹ stated that bombs exploding within buildings would produce blast effects greater than those in the open because of reflectance of shock waves from the walls, thereby producing a "prolonged pressure." The present study was undertaken to make some measurements on the degree of amplification of blast effect occurring in a cave and to delineate the effective radius of the blast resulting from a typical small charge of high explosive.

The sudden death which is unaccompanied by external injury, and yet resulting from trauma induced by high explosives, has excited interest for many years. This effect was popularly expressed in the early nineteenth century as due to "the wind of the shot" and a death presumably resulting from this was reported by McTernan in 1812.² However, serious attempts at elucidation of the pathogenesis and pathology of blast injury did not come until during World War I. Nothing specific in the pathologic picture had been shown until Carver and Dimsley,³ Mauret and Durante,⁴ and Hooker⁵ reported the presence of pulmonary lesions in experimental animals. Current experience indicates that gross damage of the lungs occurs in both experimental and clinical blast injury. Pulmonary lesions are of indisputable importance in the blast syndrome, but Stewart and associates¹¹ felt that more subtle injury to the central nervous system is actually responsible for the fatalities.

Blast is simply a very intense sound wave set in motion by the detonation of an explosive.^{1, 4, 12} It is composed essentially of a positive and a negative phase. The positive wave consists of a rapidly traveling shell of compressed air which acts in all directions by hydrostatic pressure. Although the initial pressure may be thousands of pounds per square inch, the pressure falls off rapidly with the square of the distance. The negative wave which is the relative vacuum existing behind the positive pressure shell cannot exceed 15 pounds per square inch. It is of importance to note that blast waves can be reflected from surfaces. Accordingly, individuals within enclosures are provided protection from explosions occurring in the open.¹⁰

It is generally assumed that the high positive pressure waves produce the blast injury by a purely mechanical traumatic effect but there has been con-

siderable discussion as to the possible effects of the negative phase Zuckerman¹⁴ has shown that various animals subjected to the compression phase alone exhibited the pathologic changes found in patients suffering from blast Latner⁷ has produced similar lesions in mice exposed momentarily to low pressure The use of animals of this size limits the application of his results since sensitivity to blast varies inversely with weight of the animal Additional evidence on the cause of typical blast effects has appeared in general reviews on the subject of blast^{6, 14}

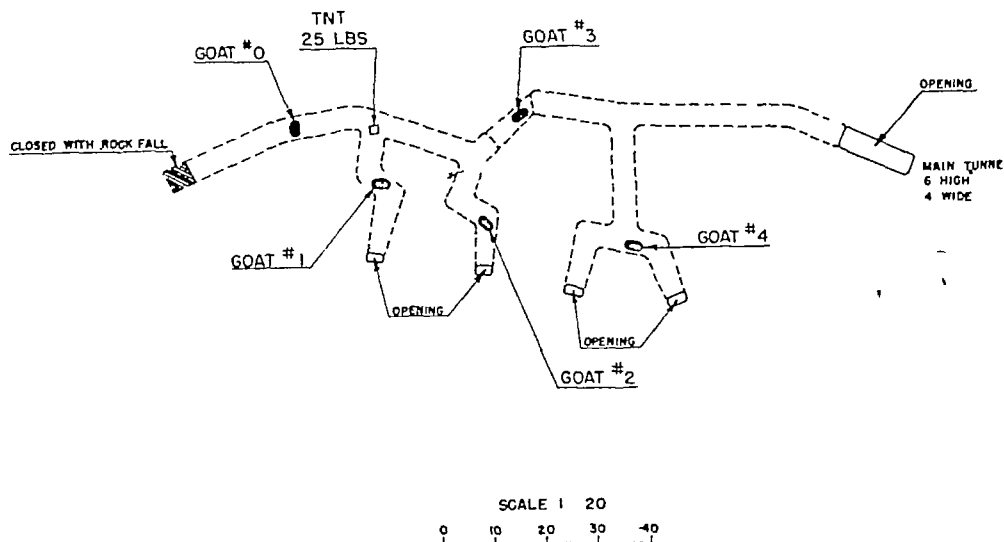


Fig 1—Spatial relationship of goats and explosive Outline of cave is superimposed on the positions occupied by the goats

The syndrome of air blast injury has been clearly described Depending upon the size and effectiveness of the charge in relation to the protection afforded by distance and shielding, the extent of the injury may vary from undetectable changes to death itself Cyanosis and dyspnea frequently occur as indications of lung injury There may be coughing and chest pain, sometimes accompanied by hemoptysis Although physical examination of the chest at first may reveal but little, the radiologic picture usually shows mottling due to pulmonary hemorrhage However, physical signs of consolidation and/or pleural effusion may become evident the next day Injury to the ears is common² Tinnitus, deafness, pain, hemotympanum, or perforation of the drum may occur

Pathologically¹⁴ the most striking and consistent findings are localized in the lungs Grossly, the lungs present hemorrhages of various shapes and sizes Linear hemorrhages are found along the rib lines Emphysema, atelectasis, and lacerations may also be present Microscopically, the lungs show alveolar hemorrhage, emphysema, and edema Any of the other tissues of the body may be sites for hemorrhages Rupture of organs, such as the liver, is found occasionally



Fig. 2



Fig. 3



Fig. 4

Fig. 2 —Lungs of Goat 1. Incisions made at autopsy indicate extensiveness of pulmonary hemorrhage in lethal blast injury. Note emphysematous right apex.

Fig. 3 —Appearance of lungs of animals exposed to blast in cave. Lungs of Goat 1, not shown here (see Fig. 2).

Fig. 4 —Appearance of lungs of animals exposed to blast in open. Compare with Figs. 2 and 3.

METHOD AND RESULTS

Since physical methods of measurement may be subject to considerable error, animals were employed as biologic indices of blast. Five goats (60 to 80 pounds), staked in a rock tunnel, were exposed to the detonation of twenty-five pounds of paper-encased trinitrotoluene (TNT) which had been placed on the cave floor (Fig 1). An additional five goats and twenty-five pounds of TNT were placed in a flat open area in positions identical with those in Fig 1, and the explosive was detonated. All the animals were examined immediately after the explosions. The cave explosion killed two goats instantly. None of the goats in the open was killed. Exactly three hours later all live goats were killed by an intracardiac injection of magnesium sulfate and were then autopsied. Each animal was carefully examined for evidence of external injury. The thoracic and abdominal viscera were inspected grossly. The lungs with some intrathoracic trachea were weighed to the nearest quarter pound. Sections were made of the lungs. A summary of the positive findings in each goat is presented in Table I. The injured lungs are shown in Figs 2, 3, and 4. The microscopic pattern invariably consisted of hemorrhage, edema, emphysema, and tearing of the alveoli. In Goats 0_c and 1_c the hemorrhagic aspect overshadowed the other findings. The sections revealed the tissues to be entirely filled with blood. In view of the similarity of this picture in all injured lung areas, individual findings have not been included in Table I.

DISCUSSION

The results are a demonstration that the blast effect of explosives detonated in small enclosed spaces is far greater than in the open. Two of the goats in the cave were killed and a third suffered moderate blast injury. On the other hand, none of the goats in the open was killed and only one suffered moderate blast injury. The heightened blast pressure in the cave is also indicated by the fact that two goats in the cave were hurled ten to twelve feet while none of the goats in the open were even torn loose from their stakes. The potentiation of the blast wave, probably due to reflection, is greatest in the immediate vicinity of the blast. The presence of sharp turns in the cave acted as baffles and prevented maintenance of the full magnitude of the reflected wave throughout the cave, since Goats 3_c and 4_c suffered only slight, or no, injury.

Pulmonary damage, as the most constant finding in animals subjected to blast, was used as a yardstick in determining effectiveness of charge. Since the majority of these lesions was found to extend in from the surface of the lungs (Fig 2), the external appearance served as a rough indication of the degree of blast injury. Therefore, the potentiation of effect within caves can be shown by comparing Figs 3 and 4. The lungs from Goat 1_c were not included in the group photograph of the cave animals as they were used to illustrate the depth to which the hemorrhages extended into the lung tissue (Fig 2).

The blast-injured lungs showed hemorrhage, edema, and emphysema. The increase in the weights of the lungs from one to three pounds (Table I) reflects the degree of edema and hemorrhage present. In the fatal cases, additional interesting findings included hemoperitoneum, diaphragmatic hemorrhage, lacerations

of the liver, tears in the wall of the stomach, massive mediastinal emphysema, and emphysematous bullae in the pericardium. Microscopically the lungs revealed hemorrhage, edema, emphysema, and tearing of the alveoli. The occur-

TABLE I SUMMARY OF POSITIVE AUTOPSY FINDINGS ON GOATS EXPOSED TO DETONATION OF TWENTY FIVE POUNDS OF T.N.T

GOAT NUM BER*	AIR BLAST DIS TANCE†	EXTERNAL APPEARANCE	THORAX	ABDOMEN	AIR BLAST EFFECT
<i>A Goats in Cave</i>					
0 _c	16	Dead, thrown 12 ft, horns broken, bloody froth in mouth and nostrils, conjunctival hemorrhage	Clot (100 cc) in right pleural space, mediastinal emphysema, extrapleural linear hemorrhages, eight air blebs in pericardium, trachea and bronchi filled with pink froth. Lungs, 3 pounds, massive hemorrhage throughout, subpleural bullae	Clot (100 cc) in peritoneal cavity, hemorrhages in diaphragm, liver, three lacerations, duodenum, subserosal hematoma	Lethal
1 _c	11	Dead, wedged in opening 10 ft away	Clots, bloody froth and submucosal hemorrhages in trachea and bronchi, lungs, 2½ pounds, massive hemorrhage throughout	Gastric contents in peritoneal cavity, hemorrhages and two tears in wall of stomach	Lethal
2 _c	35	Dazed, dyspneic	Numerous submucosal hemorrhages in trachea and bronchi, lungs, 1½ pounds, six hemorrhagic rib markings on right lung	Petechial hemorrhages on liver surface	Moderate
3 _c	33		Lungs, 1 pound, solitary hemorrhage in each lung		Slight
4 _c	78		Lungs, 1 pound, several small hemorrhages in each lung		Slight
<i>B Goats in Open</i>					
0 _o	16	Dazed	Bloody froth in trachea and bronchi. Lungs, 1½ pounds, large hemorrhage (9 by 3 cm) in right lung, many small hemorrhages on lateral surface of left lung		Moderate
1 _o	11		Lungs, 1½ pounds, emphysema of right upper lobe, several small hemorrhages and areas of emphysema in left lung		Slight
2 _o	29		Lungs, 1 pound, six small hemorrhagic areas on right and left lung		Slight
3 _o	29		Lungs 1½ pounds, several small linear hemorrhages in right lung, internal hemorrhage in left lower lobe		Slight
4 _o	55		Lungs, 1 pound		None

*Goat in cave and its control in identical position in open (Fig 1) have same number being differentiated by subscript c or o

†Refers to tunnel distances for cave goats and to straight line distances for goats in open

rence of air in the mediastinum and the pericardium (Goat 0_c) has not been previously reported in experimental animals subjected to high explosives. Theoretically, emphysema of the mediastinum might be expected to occur frequently as air from the ruptured alveoli should migrate through the pulmonary interstices. Its presence there would interfere with pulmonary and cardiac circulation producing chest pain and dyspnea.

The preponderance of pathologic findings in goats in the cave indicated the increased effectiveness of high explosive when detonated in a closed space. In extending these data to man it must be emphasized that the results would be qualitatively the same. However, quantitatively, the effect would be less, since man, due to his greater weight, is much less sensitive than the goat to blast pressure waves.

SUMMARY

Goats in a cave and in the open were exposed in identical positions to the detonation of twenty-five pounds of TNT. The results indicated that the blast effect of high explosives in closed spaces exceeds that in the open.

We wish to express our appreciation to Mr. H. Coopmans for the color photography.

REFERENCES

- 1 Bernal, J. D. *Nature*, London 147: 594, 1941.
- 2 Barrow, D. W., and Rhoads, H. T. *J. A. M. A.* 125: 900, 1944.
- 3 Carver, A., and Dinsley, A. *Brain* 42: 113, 1919.
- 4 Finch, G. I. *Nature*, London 147: 501, 1941.
- 5 Hooker, D. R. *Am. J. Physiol.* 67: 219, 1924.
- 6 King, J. D., and Curtis, G. M. *Surg., Gynec. & Obst.* 74: 53, 1942.
- 7 Latner, A. L. *Lancet* 2: 303, 1942.
- 8 Mairet, A., and Durante, G. *Rev. neurol.* 35: 97, 1919.
- 9 McTernan, J. *Lancet* 1: 385, 1943.
- 10 Sectional Steel Shelters. Report Upon Investigations of the Standard of Protection Afforded, Sessional Papers of The House of Commons, vol. 9, 1939.
- 11 Stewart, O. W., Russel, C. K., and Cone, W. V. *Lancet* 1: 172, 1941.
- 12 Sutherland, G. A. *Lancet* 2: 641, 1940.
- 13 Tunbridge, R. E., and Wilson, J. V. *Quart. J. Med.* 12: 169, 1943.
- 14 Zuckerman, S. *Proc. Roy. Soc. Med.* 34: 171, 1941.

CLINICAL MANIFESTATIONS OF LOCAL SHOCK AND THE TREATMENT

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DEFINITION

LOCAL shock is a clinical sequence of pathologic changes exhibited after severe injuries (particularly crushing) of the extremities, characterized by local traumatic vasospasm which may extend to involve a considerable part of the extremity. Acting first as a safety reflex to stop hemorrhage and additional trauma, later it may result in capillary dilatation incompetency, or decompensation, thereby (1) preventing normal tissue metabolism (anoxia) (2) interfering with the normal interchange of tissue fluids in the region of injury with loss of plasma, (3) piling up the products of trauma (blood plasma, shredded soft tissue, fractured bone, etc.) with no effort being displayed toward their evacuation, (4) ending often in degeneration and local death of the tissue before circulatory integrity can be re-established.

The phenomenon of local shock is terminated by (1) "Nature's kindly hand" through the release of the vasospasm and the re-establishment of capillary function and equilibrium, (2) local and general measures to stimulate return of circulation adequate splinting and elevation of the extremity, cold locally, heat generally, and other recognized restorative measures used in the treatment of general shock, (3) sympathetic novocain block, (4) sympathectomy.

SEQUENCE OF APPEARANCE OF OBJECTIVE SYMPTOMS OF LOCAL SHOCK

Assuming that there has been a severe crushing injury of the leg below the knee, involving soft tissue and bone with or without compounding, there are the following changes

- 1 Almost at once at the site of crush a local area of blanching or decoloration, a cadaverish appearance with a rather distinct line of demarcation with normal peripheral color

- 2 An almost immediate retraction of the skin area involved by the decoloration

- 3 Local lividity and coldness of the area

- 4 Gradual extension of the decoloration, retraction and coldness above and below the site of injury (particularly descending). Hours may elapse during this progress. Later there is discoloration due to extravasation of free blood and traumatic debris in the tissues

- 5 Boggy swelling which often takes place due to continued vasospasm, capillary decompensation, anoxia, lack of normal tissue metabolism, interchange of tissue fluids and unabsorbed filling up of the products of trauma, which if not relieved results in tissue death and gangrene

Local shock is to the extremity (leg or arm) what general shock is to the total human organism. It is a potential forerunner of general shock. Given the foregoing hypothetical circumstances, in which there is local vasoconstriction

with an extending process, a falling blood pressure may well follow with increasing lack of oxygen and permanent tissue damage, thereby aggravating dilatation and permeability of the capillaries and the escape of plasma into the tissues to the extent that the entire circulatory equilibrium is upset. General shock will take place when this pathologic phenomenon progresses sufficiently.

Various terms have been applied to similar relatively synonymous pathologic phenomena as¹⁻⁷ arterial stupor, arterial confusion, arterial spasm, traumatic segmentary inhibition of the arteries, traumatic vasospasm, and Zudach's syndrome. However, it seems appropriate and less confusing to classify this phenomenon, which is so typical in extremity injuries, as local shock in contrast to general traumatic shock. Both of these types of shock may be aggravated by laceration, contusion, or concussion of the vessels in the region of injury and respond to a sympathetic nerve reflex.

It has long been recognized that a shell fragment may damage tissue near an artery and cause segmental spasm. Injuries near the knee joint (bumper fractures⁸) or humeral supracondylar fractures (Volkmann's) are prone to exhibit arterial spasm.⁹⁻¹⁰ We have seen the phenomenon also in fracture dislocations of the shoulder and simple fractures of the midshaft of the radius and ulna, due to being struck by a tire rim when a newly repaired tire exploded while being filled with air. In a few instances of simple and compound fractures below the knee due to kicks, falls, and crushing by farm and other machinery, we have been able to demonstrate vasospasm or its sequela surgically without gross evidence of vessel injury. The following case is a very striking example.

CASE REPORT

CASE 44 348—A 56 year old farmer, Mr. R. H., in the spring of 1944, was forced to crank the motor on his truck. The truck chanced to be in gear and he was shoved violently against the end of the garage, resulting in a simple mildly oblique fracture of the upper end of the right tibia with very minor displacement. He was taken by car a matter of about ten miles to his physician, a very conscientious and observing practitioner who, after x-ray examination (Fig. 1) decided that the position of the fragments was sufficiently satisfactory to justify merely applying well padded plaster splints from the toes to the groin with the knee flexed about fifteen degrees. At the time the cast was applied he noted that there was no contusion of the skin, bruising, or even swelling despite the fact that it had been a matter of hours since the injury. For that reason he split and spread the splint the full length immediately after application in anticipation of any constriction. The toes felt cold and the extremity lacked normal color but the weather was cold and the patient had experienced considerable exposure. After hours of observation, stimulation, and general warming up, the patient felt fine and insisted upon returning to his farm. The doctor called on him the following day and noted that the decoloration of the toes and the coldness had increased but there was no swelling. Later, in consultation by telephone he was advised that from the description of the case he was dealing with a local shock phenomenon, and that an immediate lumbar sympathetic novocain block would be in order. Rain made the roads impassable and before the patient could be prevailed upon to be moved almost two weeks had passed and the toes were distinctly gangrenous. Once in the hospital, examination revealed no dorsalis pedis or posterior tibial pulsation. The toes were dry and gangrenous. The plantar, Achilles, and medial dorsum surfaces of the foot were black. There was an area on the anterolateral mid portion of the leg that was gangrenous. The upper calf was soft and boggy and slightly swollen (Fig. 2). The rest of the leg was decolored.

and cadaverish. The temperature (thermocouple) of the anterior lower leg was seven degrees lower than that of the opposite leg. Of course, this was a case for amputation. That evening, to justify the opinion that these findings were the result of persistent vasospasm and constituted the sequelae of local shock, a lumbar sympathetic novocain block of the second to the fifth lumbar vertebrae was performed and within five minutes the temperature was raised 5 degrees, or within 2 degrees of the opposite leg. A distinctly normal color came to the living integument, and in the morning before amputation the temperature was within $2\frac{1}{2}$ degrees of that of the left leg. However, the site of the fracture and the extensive muscle and skin gangrene warranted supracondylar amputation. The patient made an uneventful recovery and returned to his farm work with prosthesis.



Fig 1 (Case 44-348)—X-ray views of simple oblique fracture of upper tibia (bumper fracture) with but slight displacement.

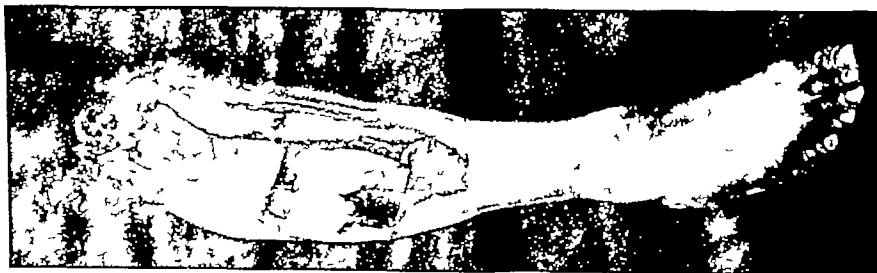


Fig 2 (Case 44 348)—Amputation specimen after examination by pathologist. Note the gangrenous foot and upper tibial region. Also no evidence of swelling except in upper calf.

A careful dissection and examination of the specimen was made by a pathologist, who found absolutely no evidence of injury to the popliteal artery or its branches. A small adherent clot was found in the anterior tibial artery just below the bifurcation which in no wise obliterated the lumen. There was no microscopic evidence of injury in sections of the vessels. The venous system seemed to be intact. There was extensive degenerative change in the large muscles of the calf.

Here was a case of local shock without general shock after an injury that was not considered very severe. Local shock and vasospasm of the brachial artery and its branches in a compound supracondylar fracture of the humerus which was relieved by reduction of the fracture have also been demonstrated.

Here early débridement, reduction, and adequate splinting played an important part in the relief of spasm while in the former case of the fractured tibia the reduction and splinting were not factors in relieving vasospasm

TREATMENT OF CIRCULATORY DISTURBANCES OF THE EXTREMITIES FOLLOWING FRACTURE OR SEVERE TRAUMA

A Prophylactic

- 1 Adequate first aid, "splint 'em where they lie", traction splints preferred, avoid constriction
- 2 Early reduction and suitable fixation, limb moderately elevated, avoid constriction
- 3 General measures to prevent thrombosis, as
 - a Anticoagulants
 - b Hydration
 - c Keeping abdominal pressure down
 - d Regular breathing exercises
 - e Preventive measures against general shock
- 4 Constant observation of circulation, ice bags locally, heat to other parts

B Nonoperative Treatment

- 1 Continued prophylactic measures (see A, 1-4)
- 2 Relief of vasospasm
 - a Parasympathetic stimulants
 - b Procaine block of the controlling sympathetic nerves (5 or 10 c c, 1 per cent procaine to each segment)

C Operative Treatment

- 1 Incision, release of subfascial pressure, reduction of fracture pressure on vessels and tissues
- 2 Ligation, excision, or plastic repair, local stripping of paravascular sympathetics
- 3 Thrombectomy or embolectomy
- 4 Sympathectomy
- 5 Amputation

RESEARCH DATA WITH RESPECT TO TREATMENT OF LOCAL SHOCK

The use of a novocain block and its effect on the sympathetic mechanism in the treatment of local shock was stimulated particularly by the observations of Ochsner and DeBakey^{11 13} with respect to the favorable results achieved by this method of releasing the vasoconstrictor mechanism in thrombophlebitis. Also, the observations of Leriche and Fontaine,¹⁴ Smithwick and White,¹⁵ White,¹⁶ and Moon¹⁷ in this relation were of importance. There seems to be a direct similarity between the traumatic circulatory phenomenon observed in local shock and that caused by a local infective process in the circulation (thrombophlebitis) which often proves to be a complicating circumstance.

Late in 1941 I started an experimental study to evaluate the significance and influence of a novocain block of the sympathetic control mechanism of an in-

jured extremity This work was augmented by a grant from the National Research Council and carried out in the laboratories of the College of Pharmacy of the University of Nebraska A preliminary report was given at the annual meeting of the American Academy of Orthopaedic Surgeons (Chicago, Ill., January, 1943)* and then presented in complete form at the annual meeting of the American Orthopaedic Association (Cleveland, Ohio, June 8, 1943)

Fig 3

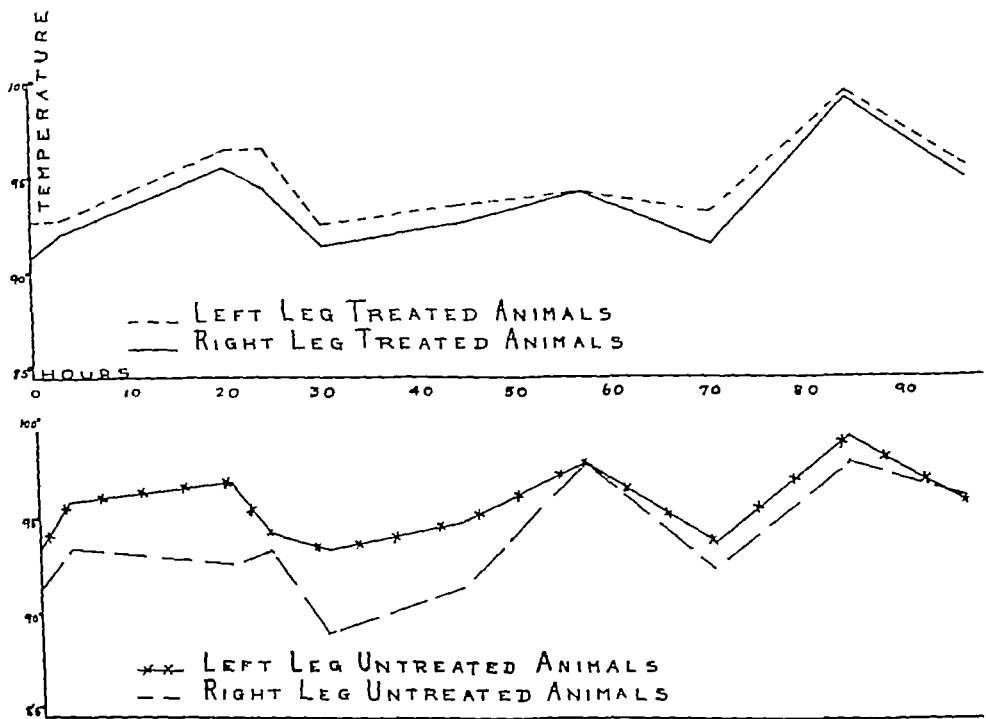


Fig 4

Fig 3—Graph of temperature (thermocouple) recordings of animals having right stellate novocain block following injury. Note how closely parallel the temperature curve of the injured right extremity follows that of the uninjured left extremity. (From Thomson James E M Helwig Ferdinand and Sire Eugene J Bone & Joint Surg 26 4 1944)

Fig 4—Graph of temperature (thermocouple) recordings of animals having no treatment following injury. Note the marked difference in the temperatures of the right injured extremity in relation to that of the left normal extremity (the right being much of the time 4 to 5 degrees colder than the left). (From Thomson James E M Helwig Ferdinand and Sire Eugene J Bone & Joint Surg 26 4 1944)

Briefly the procedure was as follows

1 The albino rabbit was selected because the appearance of changes in the blood vessels of the ear are discernible. The right upper extremity of the animal was selected for injury because its sympathetic control comes from the right stellate ganglion. This ganglion similarly controls the blood vessels of the right ear and eye. Therefore, when a novocain block of the right stellate ganglion was accomplished the accuracy of the dilatatory phenomenon was observed in the eye and ear. More than 300 rabbits were sacrificed during the study and finally

*This report was published in J Bone & Joint Surg 26 180-196 1944.

when a satisfactory sequence of technique was developed, 100 animals were consecutively observed and reported. They were all from the same stock, between 2 and 3 months old, and about 1,600 Gm in weight.

2 An instrument was devised that would deliver a crush fracture of the right humerus with equal violence and at the same site. This fact was substantiated by roentgenographs.

3 Four hours after injury the region of the right stellate ganglion of fifty of the rabbits was injected with 3 cc of 2 per cent novocain solution. Each rabbit showed dilatation of the vessels of the ear.

4 Thermocouple temperature readings were made of the right and left forelegs of each rabbit at regular intervals (every four hours). The room was kept at a temperature of approximately 70° F. These animals were identified by number. Fifty rabbits having a novocain block of the right stellate ganglion were designated as *treated* in contrast to the fifty control animals (those not having a stellate block) which were termed *untreated*.

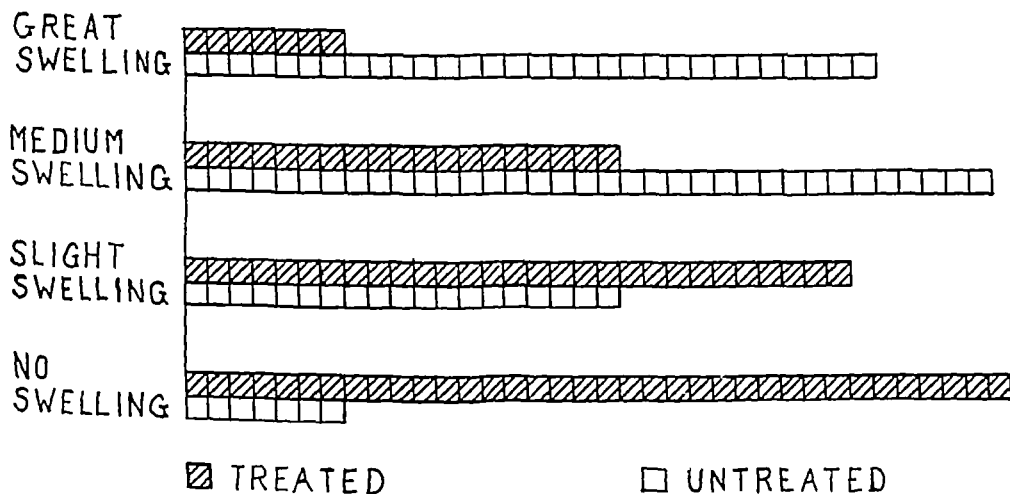


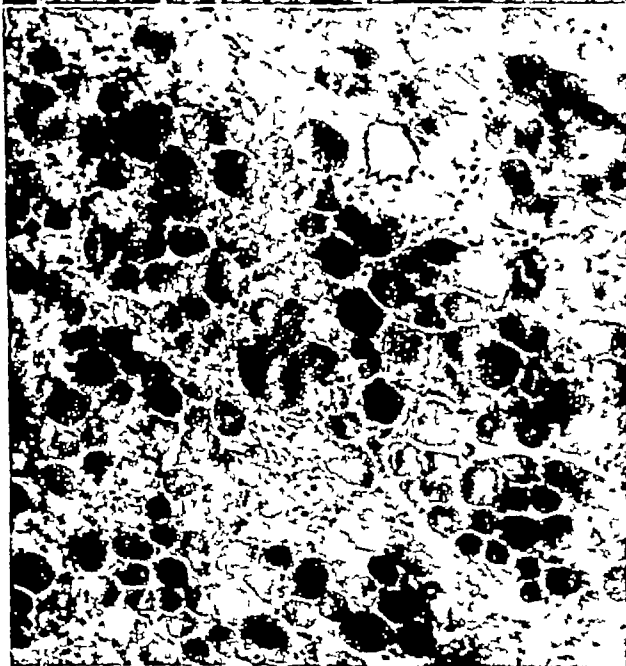
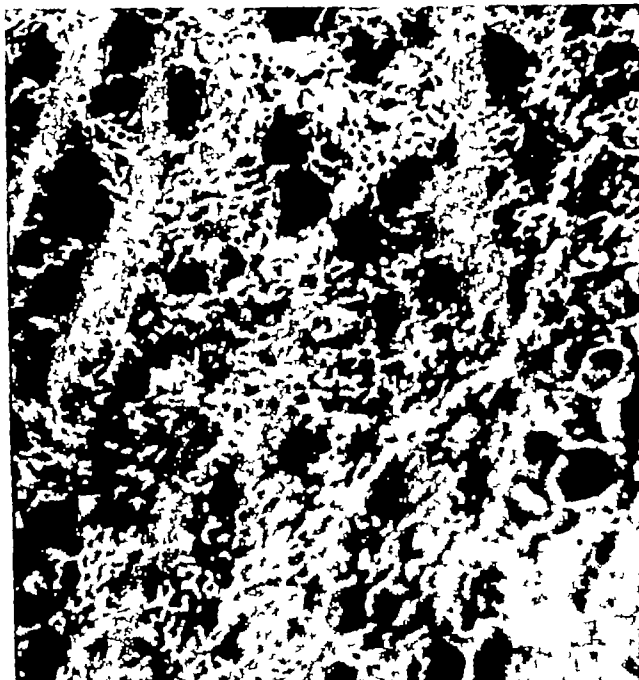
Fig 5—The shaded squares are estimations of the amount of swelling in the right injured extremity of animals having right stellate novocain block. The clear squares are similar observations of the control animals that had no treatment. Note that great and medium swellings are very pronounced in the control group while in the treated group the opposite occurs. (From Thomson, James E. M. Helwig, Ferdinand and Sire Eugene J. Bone & Joint Surg 26: 6 1944.)

5 A glance at the composite graph (Fig 3) demonstrates the fact that in those fifty animals having an injection of the stellate ganglion the temperature of the injured right leg ran slightly lower (from one to two degrees) and on a parallel course with that of the left uninjured leg.

6 A similar observation of the other graph (Fig 4), illustrating the composite temperature curve of the fifty control animals, shows a wide variation in the temperature of the injured and uninjured extremity (the extreme of 5 degrees to 6½ degrees).

7 At regular intervals observations were made of the swelling of the extremities as to whether there was (a) great swelling, (b) medium swelling, (c) slight swelling, and (d) no swelling. The results of these observations are shown in Fig 5. The shaded blocks show the percentage of great, medium, and

A



B

Fig 6—A, Rabbit 3 Right stellate ganglion injected with 3 c.c. of 2 per cent novocain four hours after injury. The microscopic sections show outstanding reactions of abundant fibroblastic response with one or two rather large areas of degenerated but nonnecrotic muscle and here and there focal calcified dead muscle fibers embedded in proliferating fibroblasts. Also there is organization of fibroblasts. This is a picture of an active healing process.

B, Rabbit 7 No treatment after injury. The section is made up almost exclusively of autolyzed necrotic nonviable muscle surrounded by a thin zone of fibroblasts. Sarcolemma nuclei are seldom seen. Little tissue response or active organization. A poor response to healing.

slight swelling as well as no swelling in the animals having stellate injection of the injured side. There were only a few with great swelling but a large number with no swelling. Just the opposite is the case in the control animals. The findings almost make an "X" in their opposing directions.

8 One hundred hours after injury, all of the animals were sacrificed. The entire upper extremity was amputated. Microscopic studies were made of the tissue. One illustration each of a treated and a control tissue is shown, from Rabbits 3 (Fig 6, A) and 7 (Fig 6, B). The significance of such constant findings in over 80 per cent of the tissues studied is more than coincidental.

From the findings in Figs 3, 4, and 5, we may assume that novocain block of the sympathetics controlling a severely injured extremity tends to restore circulatory integrity and equilibrium as manifest by the temperature curve and swelling response exhibited. Further, it is evidenced by the examination of the microphotographs of the tissue from the injured parts that the influence of stopping vasoconstriction also stimulates capillary competence and the interchange of tissue fluids, organization of a clot, the appearance of fibroblasts, proliferation of capillaries, calcification of necrotic muscle tissue, and an early healing process.

CLINICAL OBSERVATIONS

My opportunity to study local shock clinically has been quite limited. First, because I am not so located that I see a large number of severe injuries of the extremities, and second, because I am seeing fewer marked manifestations of local shock since I do a sympathetic novocain block almost routinely on all severe extremity injuries, if possible before distressing symptoms have an opportunity to display themselves. The following rather classical cases are illustrative.

CASE REPORTS

CASE 40 317—The man was a truck driver. His truck was forced off the road and turned over, pinning the driver under the cab and his arm in the door. He was unconscious and could not be removed for one and one-half hours until a wrecker could be secured. Examination fourteen hours later, after a 100 mile trip in an ambulance, revealed multiple fractures of the pelvis, a dislocated hip, cerebral concussion, and a severe comminuted dislocation of the shoulder with extensive soft tissue contusion, as the shoulder was pinned in the door (Fig 7). There was a complete (transitory) brachial paralysis, absence of pulse at the wrist, and decoloration and coldness of the entire extremity. The systolic blood pressure was 70. There was severe local shock of the right upper extremity and severe general shock. He had been brought to the hospital for amputation of the upper extremity. Because of the patient's precarious condition, operative procedure could not be considered at that time. Mild traction was placed on the arm, traction on the dislocated left hip, and balanced hammock traction for the pelvis. General restorative measures for shock were resorted to, but in addition a 10 cc 1 per cent novocain solution was injected into the region of the stellate ganglion (technique described by Ochauer and DeBailey) with a startling result. The radial pulse was apprehended in five minutes. The extremity became warmer and the color improved almost immediately. Twenty-four hours later amputation probabilities were forgotten and the fracture dislocation of the shoulder and the hip was reduced also. The paralysis of the extremity rapidly improved. The patient made an uneventful recovery except for the fact that he developed an aseptic necrosis of a portion of the fractured head of the humerus which had to be removed. Fourteen months after the injury he was back at his

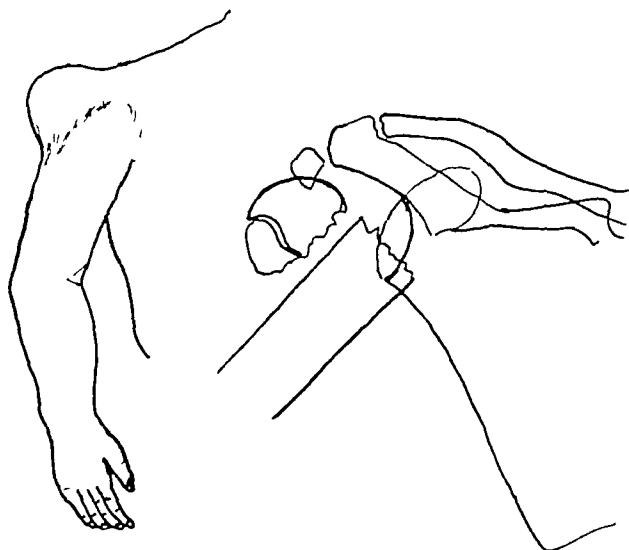


Fig 7 (Case 40-317) —X-ray tracing of shoulder fracture dislocation and sketch of deformity

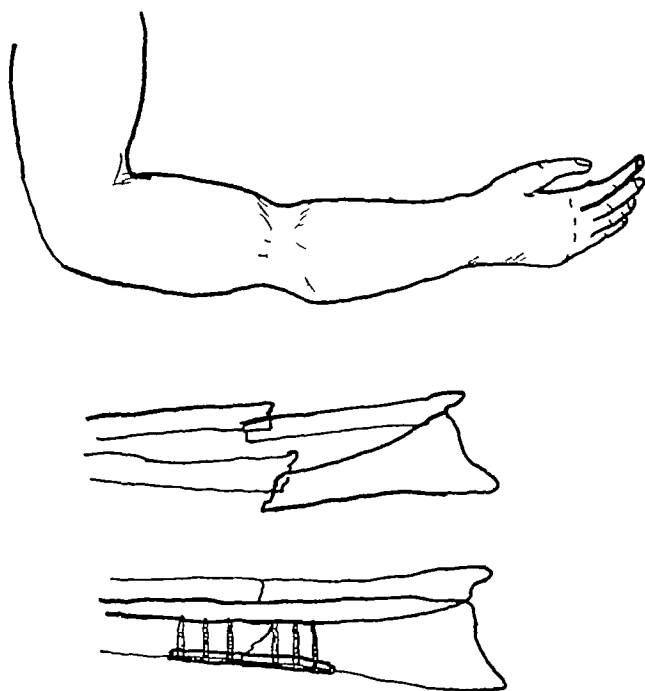


Fig 8 (Case 43-451) —Sketch of circular constricting deformity following crushing fracture of forearm Also x-ray tracings

former occupation, with some disability in the right shoulder but with good strength, which allows him to handle heavy objects in and out of the large household moving truck he operates

CASE 43-451—The patient was a man 40 years of age, a tire repairman. While in the process of inflating a repaired tire it exploded from the rim striking him across the mid forearm. A mid forearm fracture was immediately recognized and splinted in a well padded trough splint. Examination two and one half hours later showed a marked circular retraction of the skin about the middle of the forearm (Fig 8), resembling much in appearance the area of an extremity immediately after a tourniquet has been removed. There was a striking whiteness and decoloration. The radial pulse was absent but the ulnar was perceptible. The decoloration extended in degrees to the fingers, particularly the dorsal surface. Stellate block brought a prompt return of circulatory integrity but attempted reduction was unsuccessful in completely overcoming the overriding of the fragments. After one week of traction, open reduction was performed and an uneventful recovery resulted with complete restoration of function and a return to his former occupation.

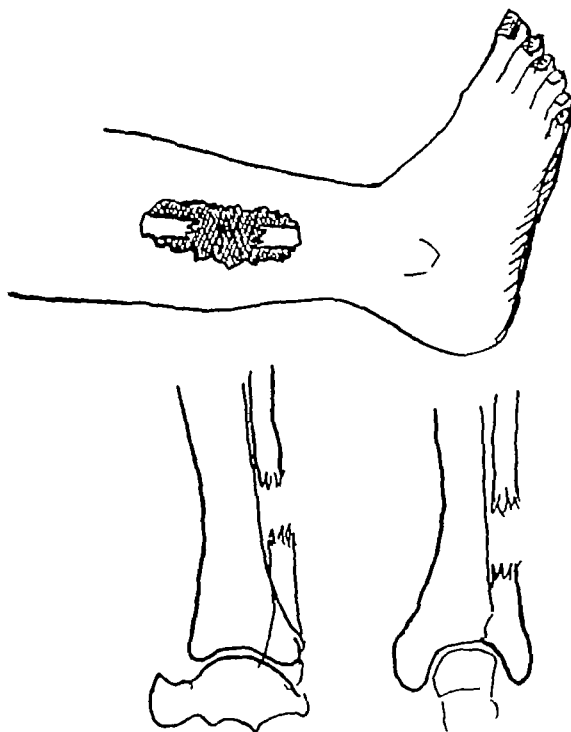


Fig 9 (Case 43-469)—Sketch of site of wound and fracture of lower third of fibula. Note there was no injury of tibia.

CASE 43-469—An 18 year old farmer fell into a combine and the left leg was caught in the machinery. A matter of one half hour was involved in extricating him and then a trip of forty five miles was necessary with a dressing over the wound on the lateral aspect of the lower third of the right leg. The tissues had been ground and chewed out of the area which appeared to be $2\frac{1}{2}$ inches wide and about $5\frac{1}{2}$ or 6 inches long (Fig 9). The black, greasy ends of the separated fragments of the fibula stood out in the crater of shredded muscle at the base. The tibia was uninjured. The margins of the wound were jagged and retracted. Decoloration of the area and of the toes was pronounced. The temperature of the toes was 5° F below that of the left foot. We felt that here we were dealing with the early symptoms

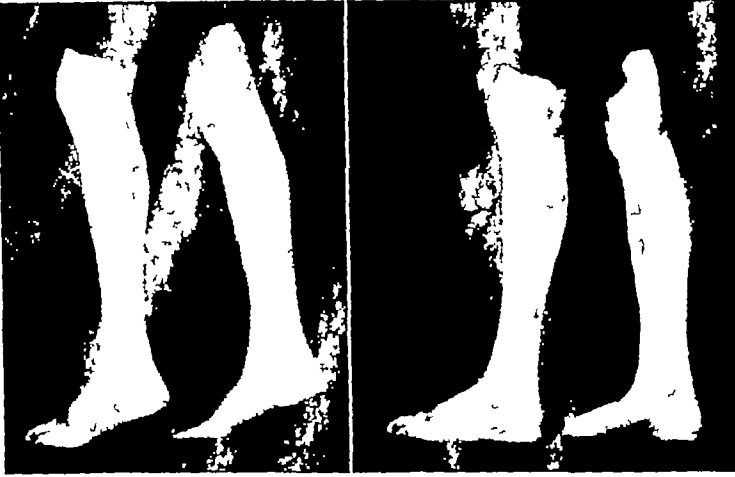


Fig 10 (Case 43-469) —Photograph of result after skin graft The fibular defect replaced itself

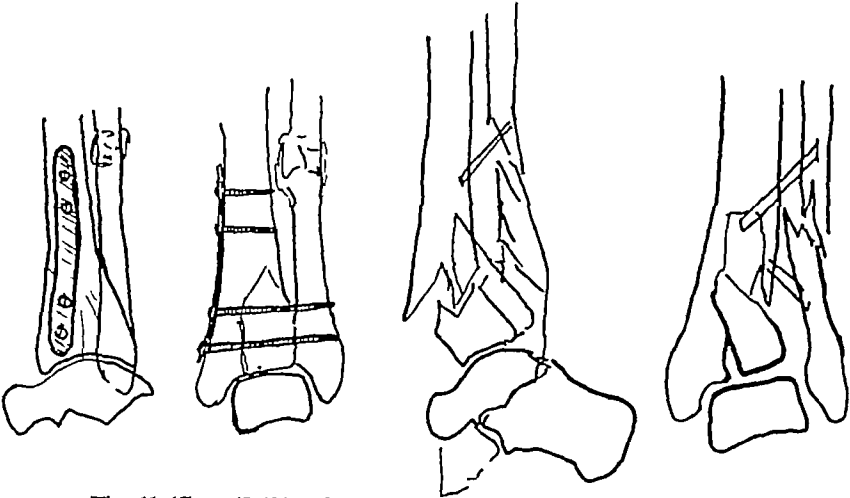


Fig 11 (Case 42-494) —X-ray tracings before and after reduction



Fig 12 (Case 42-494) —Photograph of result, good functioning ankle and foot. The pronation is about equal in both feet.

of local shock in a compound fracture in which crushing and tissue injury were not associated with loss of stability of the extremity. A lumbar sympathetic block was performed while the operating room setup was being made. By the time a complete wound toilet was accomplished the temperature of the injured foot was within $1^{\circ} F$ of the left foot. Cast fixation and sulfonamides were used and primary healing of a split skin graft took place with complete regeneration of the fibular defect and no disability (Fig 10).

CASE 42494—A 45 year old farm housewife, while getting a cow around in a stall to milk her, was kicked in the region of the left ankle. As she fell, the cow stepped on her. There was marked contusion of the tissues on the outer side of the leg, causing a very severe comminuted fracture of the lower third of the fibula and lower end of the tibia with total disruption of the ankle joint (Fig 11). When first examined twelve hours after the accident there was tremendous swelling of the lower leg and ankle. There was marked decoloration with extravasation of blood in the tissue and extensive contusion of the skin. The outer side of the ankle and the dorsum of the foot looked wet and almost gangrenous. The toes were cold and white. They were $4.5^{\circ} F$ colder than the toes of the right foot. A lumbar sympathetic block was carried out twelve and one-half hours after the injury and a good response was established. Gentle manual correction of the deformity was made and a plaster cast applied from the midthigh with the knee flexed 20 degrees and swung up in balanced suspension. Ultimately internal fixation was resorted to, thereby reestablishing the normal relationship of the bones of the ankle joint. Early active motion was established and in three and one-half months weight bearing was allowed with a brace. Although she is a heavy individual she has practically normal use of the extremity and is doing her heavy work at home as usual (Fig 12).

These are but four striking cases in a series of forty-eight experiences with the stellate and lumbar sympathetic block used to combat local shock in its various degrees of severity and as a prophylactic measure against its occurrence.

Those who are not familiar with the technique of performing the stellate and lumbar sympathetic block should familiarize themselves thoroughly with the anatomic relationships, hazards, and methods. In my experience the method described by Ochsner has proved unfailing and at the time of this writing I have had no mishaps.

CONCLUSION

The sympathetic block is not a panacea for all the grave complications of serious injuries of the extremities. It is just one infrequently used therapeutic and prophylactic measure with which the surgeon of trauma should be familiar and use with discretion more often. The more this method is used the more other potential favorable factors are recognized that occur with the earlier restoration of circulatory function which it brings to the extremity. I believe that the active restoration of tissue metabolism is a factor in inhibiting infection, promoting healing, and establishing callus in the region of fracture, thereby hastening the refunction for the extremity. Although my experimental data are inadequate to prove some of these assertions, the trend of their deductions and the clinical significance of some of the observations seem to justify the conclusions.

REFERENCES

1. Kroch, F. *Bietr. z. klin. Chir.* 97: 344, 1915, 108: 61, 1917.
2. Doucastang. *Bull. Soc. méd. d. hôp., Paris* 45: 604, 1919.
3. Soubeyran, and Michon. *Bull. Soc. méd. d. hôp., Paris* 44: 805, 1911.

- 4 Cohen, S Lancet, 707, 1941
- 5 Homans, John Circulatory Diseases of Extremities, New York, 1939, The Macmillan Company
- 6 Montgomery, A H and Ireland, J J A M A 105 1741, 1935
- 7 Henry, John P Am. J Surg 56 49, 1942
- 8 Jones, S G J Bone & Joint Surg 17 659, 1935
- 9 Jones, S G Am J Surg 43 325, 1939
- 10 Volkmann (Reprint) Jour Internat Chir 3 77, 1938
- 11 Ochsner, A, and DeBakey, M SURGERY 5 491, 1939
- 12 Ochsner, A., and DeBakey, M J A M A 112 230 1939
- 13 Ochsner, A, and DeBakey M Surg, Gynec & Obst 70 1058, 1940
- 14 Leriche, R, and Fontaine, R Presse méd 42 849, 1934
- 15 Smithwick, R H, and White, J C Surg, Gynec & Obst 51 394, 1930
- 16 White, J C J A M A 94 1382, 1930
- 17 Moon, V H Shock and Relation to Capillary Phenomena, London, 1938, Oxford University Press

MALIGNANT GRANULAR CELL MYOBLASTOMA OF THE GLUTEAL REGION

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GRANULAR cell myoblastoma is invariably considered a benign tumor and treated as such¹. It is, therefore, important to be aware of the malignant variants so that a more enlightened attitude toward treatment and subsequent follow-up may be engendered.

CASE REPORT

B G, a 21 year old woman, was first admitted to the hospital on Nov 1st, 1942. In September, 1940, the right hip was injured by a fall and a lump developed soon after in this location. It was incised by a local physician because it was thought to contain pus. Pain developed locally and in January, 1941, the tumor was inadequately excised. A short time later, a recurrence appeared, for which eight x-ray treatments were given to the region of the right hip. There was temporary relief of pain but for the few months previous to admission, it was severe and localized to the region of the right hip and sacroiliac areas.

Physical examination revealed a fairly well developed, somewhat undernourished, white woman. Over the posterolateral surface of the right hip there was evidence of radiation reaction with skin atrophy and telangiectasia. It was possible to flex the thigh, extend it, and rotate it medially or laterally with only slight pain. The right knee and ankle were normal. A roentgenogram of the chest showed evidence of early pulmonary metastases and the patient was therefore discharged without specific treatment on Feb 24, 1943 (Fig 1).

On Feb 23, 1944, the tumor had increased in size with resultant contracture of the right knee which could not be extended more than 90 degrees. A repeat roentgenogram of the chest showed progression of the pulmonary metastases (Fig 2). The views of the skull were negative. Roentgenograms of the lower lumbar vertebrae and pelvis revealed an osteolytic process involving the greater portion of the right sacral and adjacent iliac bone. Metastatic changes were also present in the left iliac bone, the pubic bone, the visualized portion of each femur, and the fifth lumbar body.

The patient became bedfast, developed decubitus ulcers, and was last admitted to the Kansas City General Hospital on April 29, 1945. Roentgenograms of the chest and pelvis showed excessive increase in the extent of the disease (Figs 3 and 4) and death occurred on July 14, 1945. Permission for post mortem examination was obtained.

Anatomic Diagnosis—Diagnosis was granular cell myoblastoma of the right gluteal region with metastases to the regional nodes, lungs, innominate bone, sacrum, and lumbar vertebrae, pyelonephritis, kidney stones, bronchopneumonia, decubitus ulcers, ascites, hydrothorax.

The body was extremely emaciated and there was a large, nonulcerated tumor mass over the right hip, which presented extreme skin atrophy and telangiectasia (Figs 5 and 6). A small decubitus ulcer was present over the sacrum. There were approximately 2,000 c.c. of fluid in the peritoneal cavity. In the right lower quadrant there was a large retroperitoneal mass which displaced the ascending colon, small bowel, and pelvic organs to the left. Each pleural cavity contained about 1,000 c.c. of clear fluid. The right lung weighed 605 Gm, and the left, 660 Gm. The surface of the lungs showed numerous nodulations of variable sizes, some of them forming grapelike masses (Fig 7). These tumor masses felt rather rubbery and, on section, were circular, homogeneous, and gray, with small areas of hemorrhage (Fig 8). They replaced about 80 per cent pulmonary parenchyma but had not ulcerated through the pleura. The bronchi and pulmonary vessels were not remarkable. The kidneys showed some small stones within the calices and the corticomedullary zone was com-

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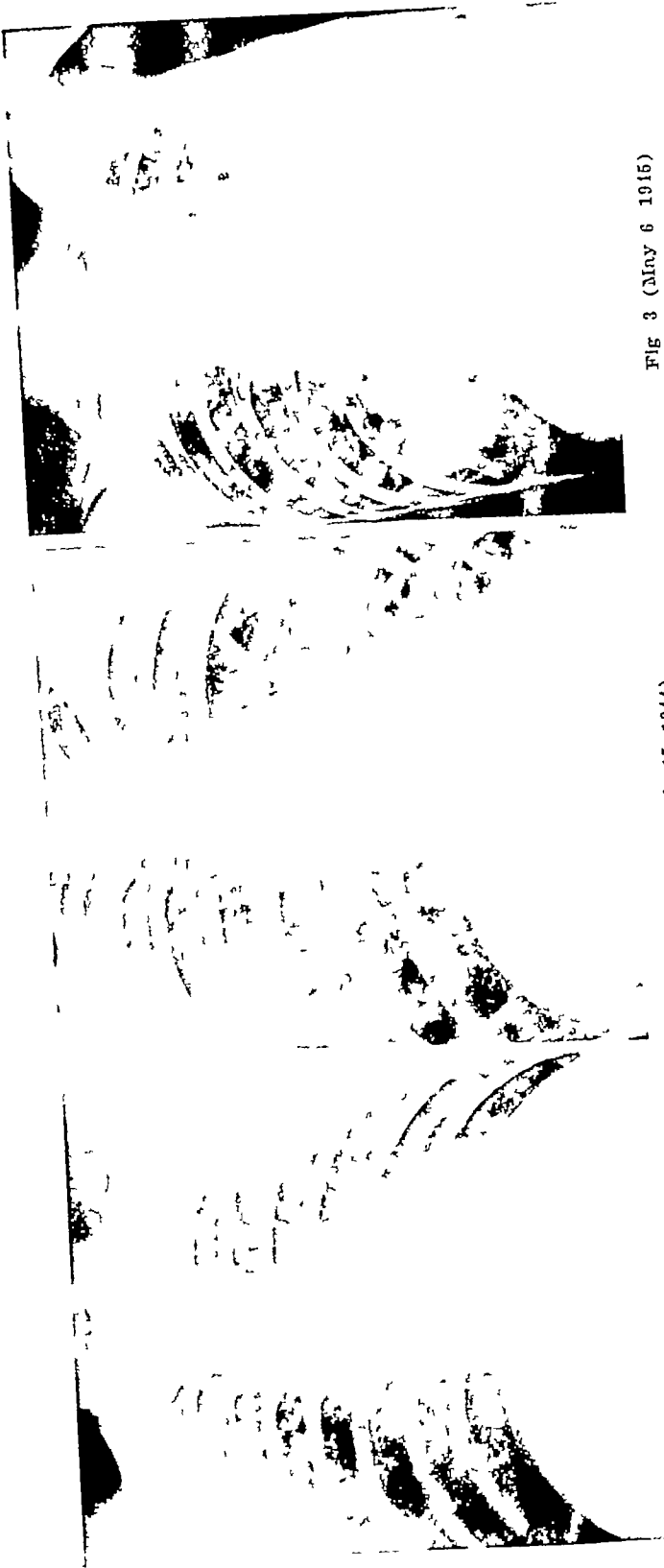


Fig 1 (Nov 14 1942)

Fig 2 (Feb 15 1941)

Fig 3 (May 6 1915)

Figs 1 to 3 —Note progression of metastases

pressed. The ureters were dilated and the bladder congested. The tumor mass in the right lower quadrant was retroperitoneal in nature and communicated with the large mass in the region of the hip. It had extended into the ilium, sacrum, and contiguous lumbar vertebrae and had partially blocked the ureters. The bone was so completely destroyed by tumor (yellow in color with zones of hemorrhage) that only small spicules remained. The brain was not remarkable.

The tumor showed a somewhat varying morphology. Tumor cells assumed at times a pseudoalveolar arrangement (Fig 9). Individual cells varied from very small to large. Often, they had coarsely granular, eosinophilic cytoplasm. In the larger cells, the nuclei were located eccentrically, while in the smaller cells, they tended to be central. The nuclei usually were well defined and had very prominent nucleoli (Fig 10). Occasional cells showed condensation of the chromatin. No mitotic figures were seen. Rather frequently, individual cells were multinucleated (Fig 12). The tumor in the lung as well as in the bone formed solid masses which were well vascularized and carried with them very little stroma. When tumor was present in a lymph node it usually completely replaced it. Tumor in the previously irradiated area showed no discernible changes. The tissue surrounding the tumor in this area did show extreme fibrosis and other expected radiation alterations.

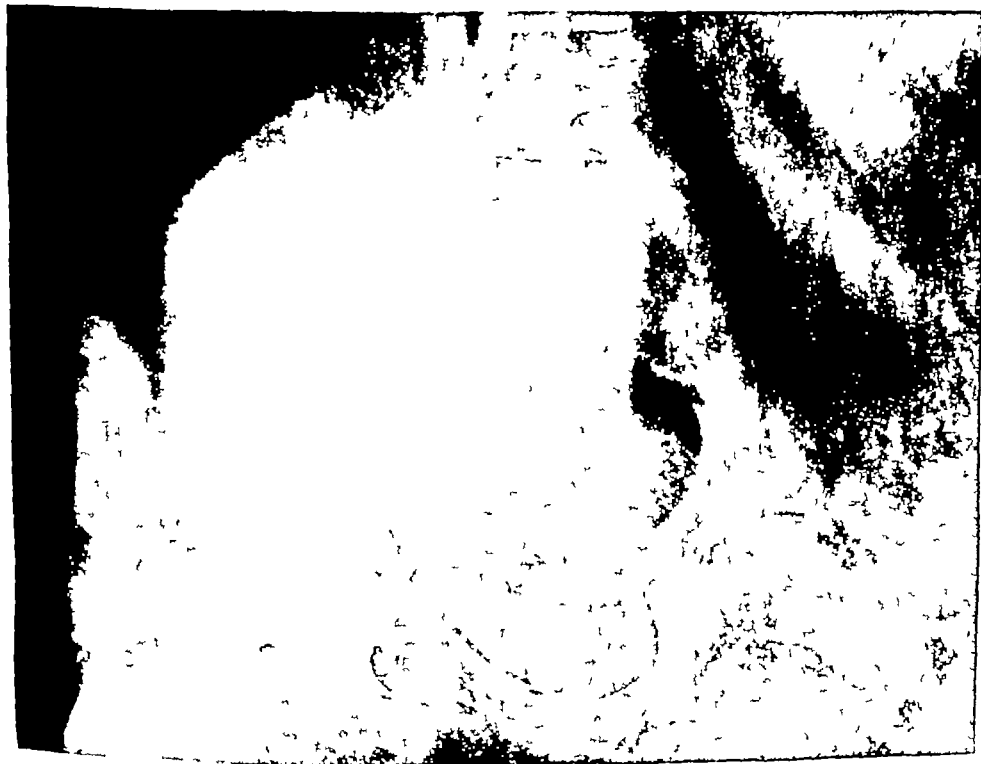


Fig 4—May 6 1945 note extensive osteolytic destruction of the innominate bone.

The tumor was fixed in 10 per cent formalin, Zenker's acetic, and 100 per cent alcohol. A determined search was made for evidence of cross striations, and in one slide, a large cell showed definite fibrils (Fig 13). There were also small groups of red granules in some of the cells, with an irregular linear arrangement which may represent the precursor of fibrils.²

Because of some cytoplasmic vacuolation in some of the cells, a stain for fat was done, showing scattered small amounts of sudanophilic substance within these areas. No intranuclear fat was present. Stain for glycogen demonstrated a peripheral intranuclear halo of glycogen by Best's carmine stain. A Wilder reticulum stain showed a rather unusual distribution of reticulum. This reticulum enclosed groups of cells (Fig 11).

Fig 5



Fig. 6

Figs. 5 and 6—Huge soft-tissue tumefaction with skin atrophy

Fig 7

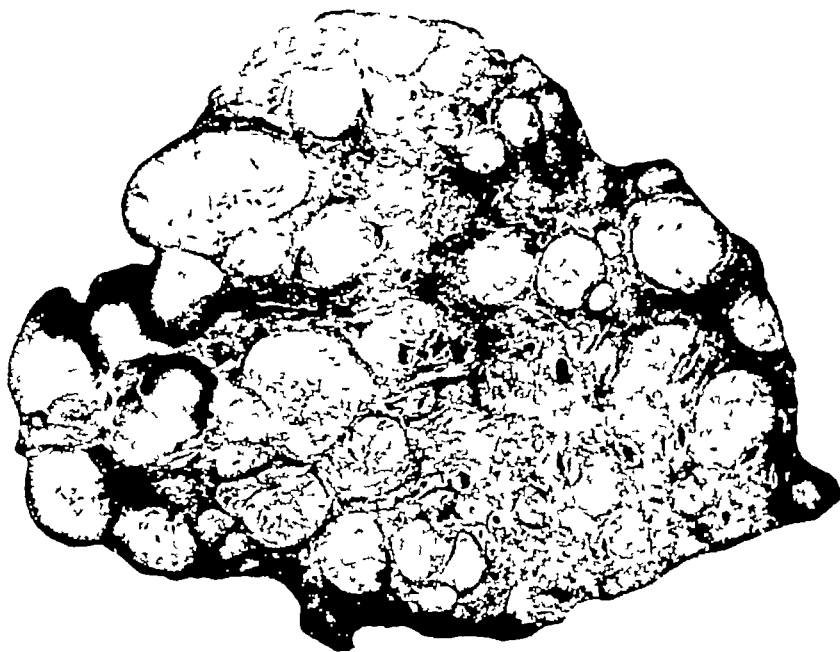


Fig 8

Fig 7—Pleural surface of lung, showing numerous tumor nodules.
Fig 8—Cut section of lung demonstrating well-delineated innumerable metastatic foci

Fig 9

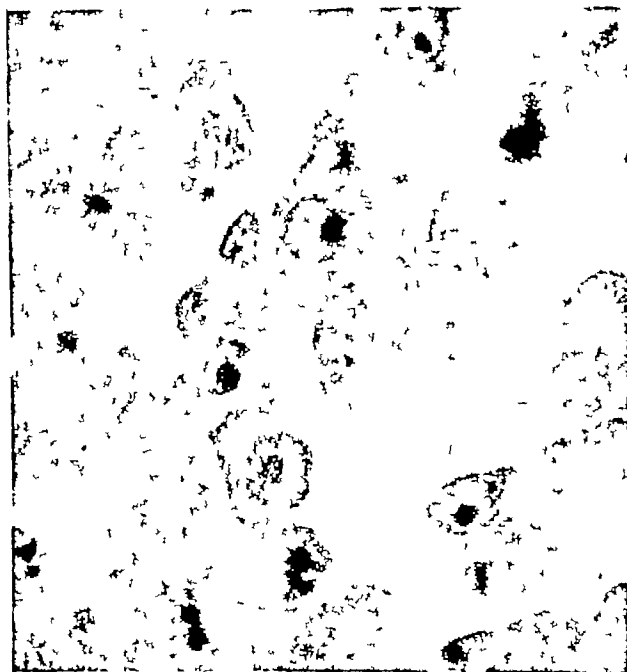
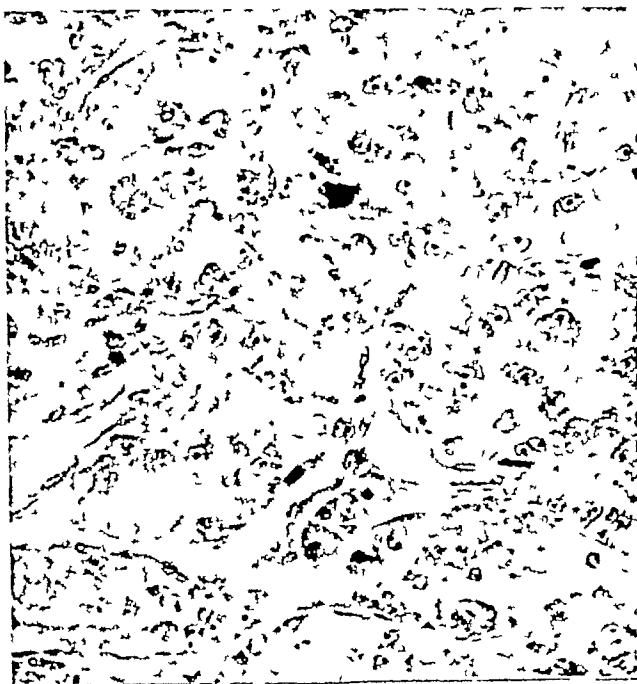


Fig 10

Fig 9—Photomicrograph (low power) pseudoalveolar arrangement of well-vascularized tumor

Fig 10—Photomicrograph (high power) characteristic well-defined nucleus prominent nucleoli, and granular cytoplasm.

Fig 11

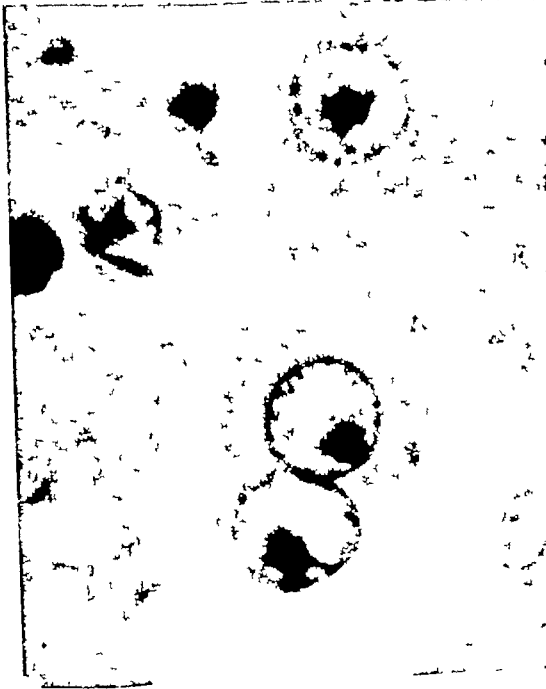
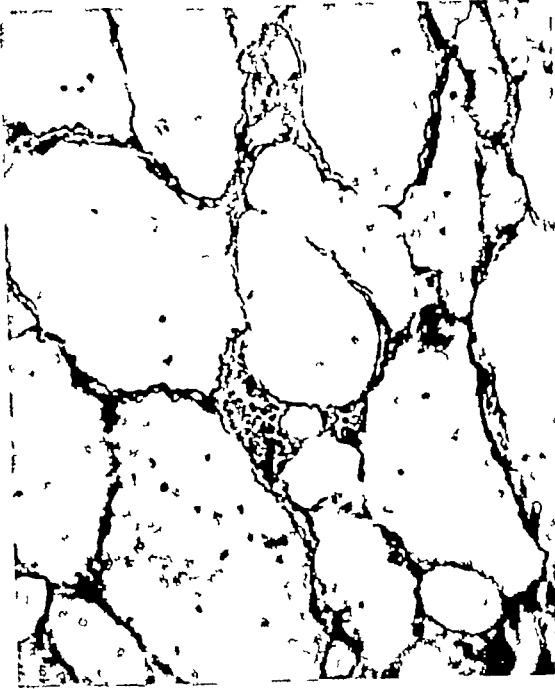


Fig 12

Fig 11—Note pattern of reticulum
 Fig 12—Photomicrograph (very high power) multinucleated cells.

DISCUSSION

Abrikossoff^{3, 4} classified these tumors into four types, the first three of which were benign and the fourth, malignant. The cellular morphology of this tumor was similar to his third type. In the benign granular cell myoblastomas, the nucleoli are not as prominent and cell variation is minimal. In Table I are represented some of the cellular differences between the benign and malignant myoblastomas.

There has been no report in the literature of a granular cell myoblastoma showing metastatic disease until recently when Ravich and associates⁵ reported one arising from the urinary bladder. The individual cellular details of our case resembled his.⁶

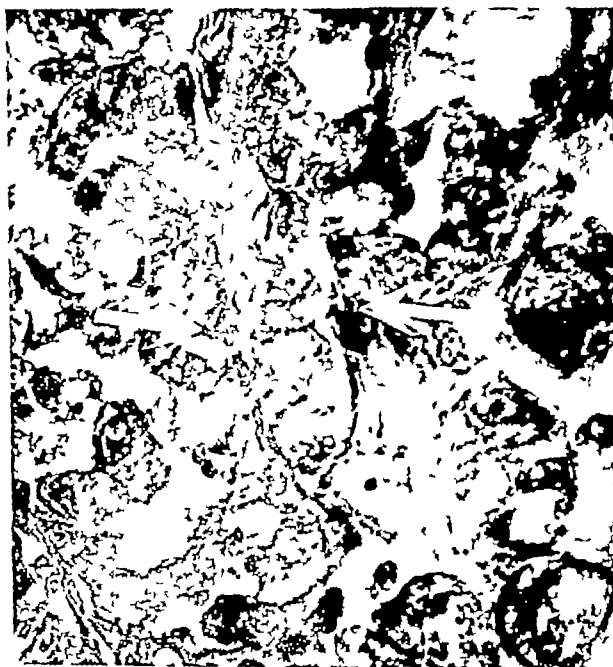


Fig. 13—Photomicrograph (very high power) note wavy cross striations in cell marked by arrows

This is apparently the first case of malignant granular cell myoblastoma arising in the gluteal region and causing death from metastatic involvement of bone and lungs. It is interesting that this patient lived almost five years after the diagnosis was made, and that there were proved lung metastases for almost three years.

If, after biopsy, there is any question of malignancy, a radical rather than a conservative operation should be done. These cases should also be followed rather more closely than has been felt necessary in the past and probably regional node areas should be watched and roentgenograms of lungs taken. If lymph node metastases develop, regional dissection may be indicated. Radiotherapy is not warranted.

TABLE I

	BENIGN	MALIGNANT	
Size of cells	20 to 60 μ , up to 100 μ	8 to 20 μ , average 4 μ	} Malignant measurements based on this case only
Size of nuclei	7 to 10 μ	6 to 17 μ , average 9 μ	
Character of nucleoli	Fine	Very prominent	
Glycogen	No available data	Intranuclear present, cytoplasmic absent	
Fat	Absent	Minimal cytoplasmic	
Longitudinal and cross striations	Present	Absent in one case (Ravich), present in our case	
Cytoplasm	Granular	Granular	

SUMMARY

A malignant granular cell myoblastoma (third group of Abrikossoff) is reported arising from the region of the right hip. It recurred and metastasized following inadequate excision and caused death approximately five years after diagnosis. This is the second example of this type of tumor metastasizing and is the first example of one in this location. It is recommended that a somewhat more cautious clinical attitude be entertained when a diagnosis of granular cell myoblastoma is made. The typical cellular morphology of the malignant variant has been detailed. If any doubt exists as to its benign character, then radical rather than conservative therapy should be instituted. Radiotherapy is not indicated.

REFERENCES

- 1 Crane, A. R., and Tremblay, R. G. Myoblastoma (Granular Cell Myoblastoma or Myoblastic Myoma), *Am J Path* 21: 357, 1945
- 2 Crane, A. R. Personal communication
- 3 Abrikossoff, A. I. Ueber Myome, ausgehend von der quergestreiften willkürlichen Muskulature, *Virchows Arch f path Anat* 260: 215, 1926
- 4 Abrikossoff, A. I. Weitere Untersuchungen über Myoblastenmyome, *Virchows Arch f path Anat* 280: 723, 1931
- 5 Ravich, A., Stout, A., and Ravich, R. A. Malignant Granular Cell Myoblastoma Involving the Urinary Bladder, *Ann Surg* 121: 316, 1945
- 6 Stout, A. P. Personal communication

DYSGERMINOMA OF THE OVARY

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COMPARATIVELY recent in medicine was the separation of this growth as a distinct type from the other neoplasms of the ovaries. Meyer¹ originally identified this tumor of the ovary which is so histologically similar to the seminoma of the testicle. Since it arises from the undifferentiated sex cells of the primitive mesenchyma of the early embryonic life, he called this neoplasm dysgerminoma. He also made three striking observations—a tendency to occur in the younger age group, predilection for the right side, and high percentage of occurrence in hermaphroditic or pseudohermaphroditic states. Some 160 cases have been reported in the literature up until 1940.

The incidence of occurrence of this type of new growth among the malignant tumors of the ovary, according to Klatfen,² has varied from 3.1 to 6.3 per cent among the groups of cases reviewed. This seems to be somewhat higher than that found in the series of the author who had 1.2 per cent. The mortality varies between 40 to 60 per cent with recurrence and metastasis about as frequent.

One of the best criterions as to the benign or malignant state is the gross findings at surgery, as those that are infiltrative and have involved the regional lymphatics are usually malignant, and vice versa.

Most frequently the patient presents herself with the only complaint being fullness in the stomach or often an actual enlargement of the abdomen. Pain, excessive bleeding, and dysmenorrhea rarely bring her to the office. At that time the pelvic examination usually reveals the adnexal mass and close observation will sometimes bring out pseudohermaphroditic characteristics, such as masculine voice or enough facial hair to require shaving. An approach to the preoperative diagnosis has been attempted by hormone studies, but as this is a sexually undifferentiated tumor, the findings are always negative and the diagnosis is made at surgery.

Although this condition occurs more frequently in the younger age group, and has been sometimes regarded as benign, it is to be stressed that it should be looked upon as malignant and should be thought of in diagnosing tumors in women at any age. Abernethy³ reported a case in a 22-year-old patient encountered during a section. Kirshbaum and Newman⁴ reported one in a 36-year-old woman and the one I am reporting is in a girl 12 years old. All three were malignant and in varying age groups. Many times this condition was diagnosed as benign by the operating surgeon only to be disproved by the pathologist's necropsy report.

The successful treatment is an early operation, for if the tumor has progressed to the extent of producing abdominal fluid, adhesive reactions to the near structures, or actual extension, then the cases are fatalities. But in those that are discrete and have had a clean surgical removal, the patients usually survive. X-ray therapy has not proved to be of value.

CASE REPORT

CASE S1279—A 12 year old Spanish girl had a chief complaint of "lump in stomach." This child had always been thin and nervous until two years before admission. At the age of 10 her mother stated she began to get "fat all over." About two and one half years before admission the patient had a complete examination in a clinic at which time all findings were negative. During a routine school physical examination two months before, a mass was found in the abdomen and the girl was sent in for diagnosis and treatment. She had no vaginal bleeding of any kind, not having started to menstruate, but the breasts had become more developed in the previous three or four months. Other history was entirely uninformative as the patient was quite normal in habits, growth, and associations.

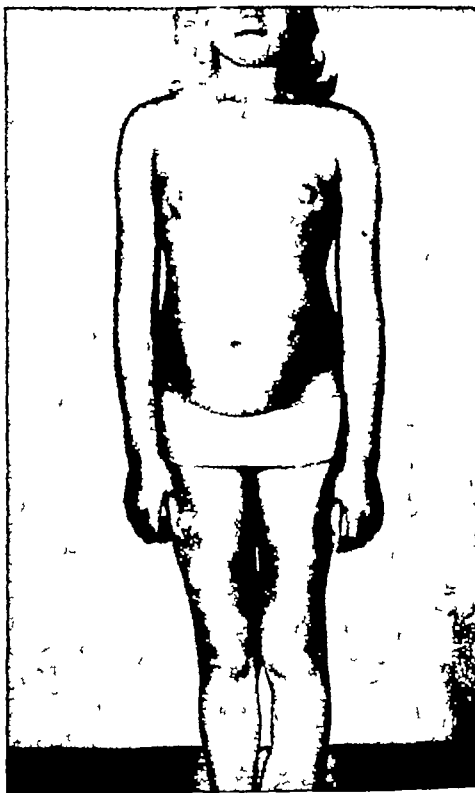


Fig 1—Normal 12-year-old girl, except for evident abdominal enlargement.

Physical examination on entrance revealed a 12 year old girl, feminine in type, well nourished, in no acute distress. Temperature and pulse rate were normal. Breasts were beginning virginal development. The abdomen was rounded and there was beginning pubic hair which had normal female distribution. There was a firm, nontender, irregular, freely movable mass to the left. The lower border was resting on the pubic, medial border at the midline, and superiorly two fingers above the umbilicus. On rectovaginal examination the uterus could not be differentiated from the mass above.

Laboratory procedures were normal, x-ray examinations of the chest and bones were negative. Roentgenograms of the abdomen showed a large homogeneous, soft tissue density.

A diagnosis of a left ovarian cyst was made and the patient was operated upon. At surgery there was removed a large mass replacing the left ovary. It was discrete, firm, not adhered, or infiltrating any of the abdominal viscera. The left tube, uterus, right tube, and ovary were entirely normal. No other pathology was noted in the abdomen.

Pathology Report—Following is the complete gross and microscopic report of the mass removed at surgery. From the left ovarian tumor the gross specimen consisted of a large, pale gray, solid tumor, weighing 1,050 Gm, measuring 18 by 12 by 6.5 cm. The surface was rather smooth, but slightly bosselated. At one point it was slightly puckered. The cut surface was opaque, grayish white, firm, the tissue cutting with some resistance. Scattered throughout were small patches of hemorrhage and paler semitranslucent areas of degeneration. No cystic areas were present.



Fig 2—Cut section removed at surgery numerals in inches.

Microscopically, the sections were cut from a number of various portions of the tumor. These varied from one another in appearance. The tumor cells extended outward to the fibrous capsule. No break through the capsule was observed. The tumor consisted of irregular cords and nests of large, immature-appearing cells, possessing round or polyhedral, vesicular nuclei, showing frequently one large nucleolus. These large nuclei were surrounded by a small amount of pale staining, frequently granular, faintly bluish pink cytoplasm. In other areas the cytoplasm was more reticular, and fainter staining. The cells varied somewhat in different portions of the tumor. They were supported by variable amounts of dense fibrous stroma. In the more central portions of the tumor the stroma was minimal in amount, and was infiltrated with a scattering of lymphocytes. Nearer the periphery the fibrous stroma was thicker, and occasionally supported a small rounded structure, somewhat resembling an immature follicle. Mitotic figures were present in large numbers. Many were atypical. The gross and microscopic appearance of the tumor was consistent with the diagnosis of dysgerminoma of the ovary.

The patient had an uneventful postoperative recovery, being discharged on the tenth hospital day. She was seen at various intervals at the follow up clinic, and eighteen months after surgery a complete check of the child revealed no evidence of recurrence or metastasis.

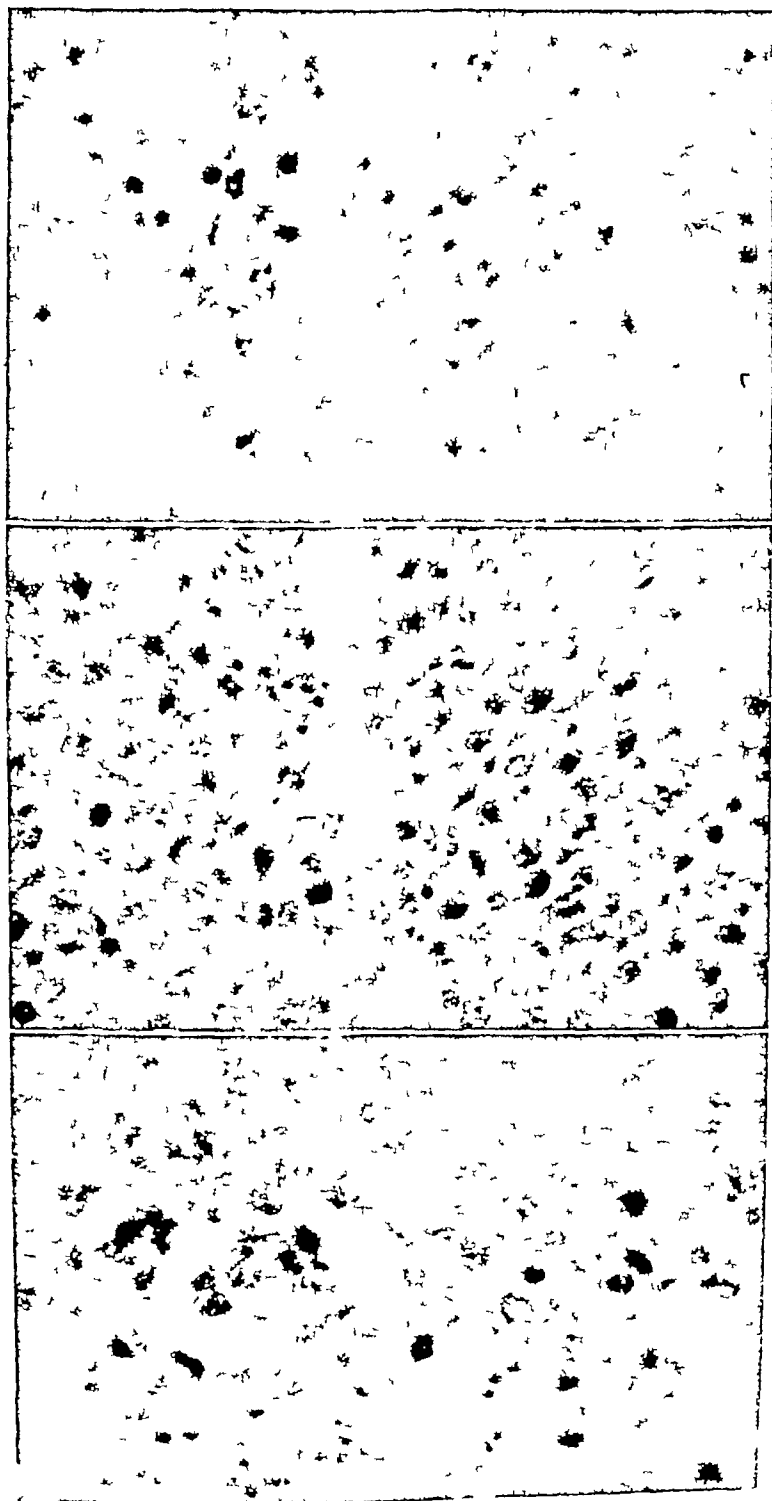


Fig 3—Microscopic section taken from gross specimen shown in Fig 2

SUMMARY

1 Review of the literature shows some divergence of opinion as to the benign or malignant state of these tumors

2 Reports of cases of survival (both in the literature and in my series) are those in which the primary growth showed no evidence of extension

3 These tumors are not radiosensitive

4 Asymptomatology, normal secondary sex characteristics, and any age group are more often found than the reverse

CONCLUSION

Having an incidence of 3 to 6 per cent among all malignant tumors of the ovary, and a mortality of 40 to 60 per cent with recurrence and metastasis as frequent, these growths have assumed an important proportion. The only hope for these patients is early diagnosis and surgery. These are malignant tumors, as all those that showed extension at the time of operation died of metastasis.

REFERENCES

- 1 Meyer, Adolph. Am J Obst & Gynec 22 1930
- 2 Kλάften, E. Arch F Gynak 158 544, 1934
- 3 Abernethy, D. A. J Obst & Gynaec of Brit Emp 50 278, 1943
- 4 Kirshbaum, J. D., and Newman, B. Am J Obst & Gynec 45 33, 1943

THE USE OF TETRAETHYLAMMONIUM IN PERIPHERAL VASCULAR DISEASE AND CAUSALGIC STATES

A NEW METHOD FOR PRODUCING BLOCKADE OF THE AUTONOMIC GANGLIA

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THERAPY in peripheral vascular disease cannot properly be applied without an evaluation of the presence and degree of vasospasm in the involved and collateral vessels^{1 9 10} In the majority of cases both a functional element of vasoconstriction and an organic component of vascular obliteration are present The functional component, since it is, for the most part, an expression of the activity of the sympathetic nervous system, may be altered, the organic component, on the other hand, is little, if ever, modified by therapeutic measures

The role of vasoconstriction has been evaluated in the past by means of local nerve block, paravertebral sympathetic block, and spinal anesthesia Recently, a new method of producing a blockade of autonomic ganglia by means of parenteral injection of the tetraethylammonium ion has been introduced It is the purpose of this report to describe the use of this compound in peripheral vascular disease and causalgic states

Acheson and Moe^{2, 3} studied the action of tetraethylammonium on the superior cervical and stellate ganglia, on sympathetic vasoconstrictor mechanisms, and on efferent vagal pathways They concluded that the response of the nictitating membrane, the blood pressure, and the heart rate could all be explained by a blockade of autonomic ganglia, both sympathetic and parasympathetic The validity of this interpretation was further confirmed by Acheson and Pereira⁴

Lyons and co-workers^{5, 6} demonstrated that the drug could be administered safely to man in doses sufficient to produce an autonomic blockade and described its action on the human subject

TECHNIQUE OF THIS STUDY

Studies on the peripheral circulation were carried out with the patient recumbent, extremities uncovered, in a room temperature between 70 and 75° F After a suitable period of rest, whenever possible, in the basal state, skin temperature readings were recorded on symmetrical areas of the extremities studied The color of the skin and the volume of the pulses were noted After suitable control studies had been made, tetraethylammonium was injected intravenously or intramuscularly in a 10 per cent solution and further observations were made* The intravenous dose ranged from a minimum of 100 mg (1 cc) to a

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*Supplied by The Department of Clinical Investigation Parke Davis & Co Detroit, Mich as Etamon

maximum of 500 mg (5 cc) This was injected slowly over fifteen to sixty seconds, using significant changes in the volume of the pulse and the general reaction of the patient as a guide to cease or delay further administration of the drug

Intramuscular injections were utilized to prolong the effect of the autonomic blockade only in patients under observation in the hospital These were given in doses less than 20 mg per kilogram of body weight, 10 to 15 Gm, one-half the dose administered in each buttock.

The intravenous administration produces a metallic taste in fifteen to twenty seconds followed by a sense of numbness and tingling in the extremities which is associated usually with a fall in blood pressure in hypertensive patients and with a rise in heart rate Sweating, if present, stops, the mouth becomes dry, and there is incomplete dilatation of the pupil with loss of accommodation. With the fall in blood pressure, there is an increase in skin temperature of the toes or fingers usually within five minutes which persists after the blood pressure returns to its initial level Though the blood pressure in the supine position returns to its initial level, postural hypotension may exist in diminishing intensity for fifteen to sixty minutes The vasoconstrictor gradient present in the extremities is largely abolished so that toe and thigh temperatures are equalized

VALUE OF TETRAETHYLAMMONIUM IN PRODUCING SYMPATHETIC BLOCK AS DEMONSTRATED BY COMPARATIVE TESTS

The comparative effects on peripheral blood flow of lumbar sympathetic block, spinal anesthesia, local nerve block, and sympathectomy versus tetraethylammonium, as measured by skin temperature and clinical response, were measured both in patients with vascular disease and in a control group of relatively healthy individuals Fifty-five comparative tests were performed (Table I) Measurements of skin temperature response were made under identical conditions in practically all cases

TABLE I COMPARATIVE SKIN TEMPERATURE RESPONSE (PERIPHERAL BLOOD FLOW) OF TETRAETHYLAMMONIUM BROMIDE AND THE USUAL METHODS OF PRODUCING SYMPATHETIC BLOCK

NUMBER OF COMPARATIVE TESTS—55	RESPONSE TO TETRAETHYLAMMONIUM BROMIDE		
	EQUAL	LESS	GREAT ^{er}
Paravertebral sympathetic block	10	2	8
Local nerve block	10	1	9
Spinal anesthesia	10	2	7
Sympathectomy	25	20	3
Total	55	25	27

It will be noted that the response to tetraethylammonium bromide was equal to or surpassed the response produced under identical conditions by paravertebral sympathetic block or local nerve block In one instance, in ten it proved inferior to spinal anesthesia, and in two instances, in twenty-five it proved inferior to sympathectomy in producing a maximal temperature response In fifty-two of fifty-five comparative tests it proved equal or superior to the usually accepted methods of producing sympathetic block The ease of

administration regarding the technical procedure is an additional highly desirable feature of tetraethyl ammonium since spinal anesthesia is not always desirable or possible and paravertebral sympathetic block, even in expert hands, is not always successful.

UTILIZATION OF TETRAETHYLAMMONIUM BROMIDE AS A DIAGNOSTIC AND THERAPEUTIC MEASURE

Approximately 500 patients have received tetraethylammonium bromide or chloride on one or more occasions either as a diagnostic or therapeutic measure, or both. These patients, for the most part, fall into two general groups, (1) patients with hypertension, and (2) patients with peripheral vascular disease and allied disorders. The various diseases studied in this latter group have included patients with peripheral arteriosclerosis obliterans (all stages), thromboangitis obliterans (including cases with migratory superficial phlebitis), functional vascular disorders including Raynaud's syndrome, livedo reticularis, acrocyanosis and other unclassified vasomotor disorders, causalgias including various types of reflex sympathetic dystrophy,¹³ superficial and deep thrombophlebitis with and without evidence of vasospasm, various types of lymphedema, post-traumatic edema, scleroderma, endarteritis, herpes zoster and post-herpetic neuralgias, trench and immersion foot sequelae, and a nondescript group of widely varying nature.

Many of these patients received courses of therapy extending over a period of several days. Others received only a single injection, usually intravenously, or were given periodic weekly or monthly injections to produce a sympathetic block as the need arose.

TECHNIQUE OF ADMINISTRATION

Tetraethylammonium bromide was administered as a 10 per cent solution (100 mg per cubic centimeter) in practically all cases. The drug was given either intravenously or intramuscularly. The intravenous dose ranged from a minimum of 100 mg (10 cc) to a maximum of 500 mg (50 cc). The drug was administered intramuscularly on the basis of 20 mg per kilogram, the maximal dose usually ranging from 10 to 12 Gm (10 to 12 cc), one-half of the total volume given being injected into each buttock. This procedure was carried out with the patient recumbent, extremities uncovered, in a room temperature of 70 to 75° F. Variation in room temperature during the test was negligible. Where possible, a basal state was employed. A blood pressure cuff was applied to the arm and one or more determinations of blood pressure and pulse determinations were made. Utilizing the same arm, and the cuff for a tourniquet, tetraethylammonium bromide 10 per cent was slowly injected, the rate and volume of injection being governed by changes in pulse volume and the general systemic reaction of the patient. An acceleration of pulse rate was usually noted, but only significant changes in pulse volume were taken as a guide to cease or delay further injection of the drug. Under no circumstance were more than 5 cc intravenously administered.

The intramuscular route was employed only in cases under observation in the hospital. The effects of the intramuscular injection of tetraethylammonium bromide usually lasted six to eight hours.

The intravenous injection produces a metallic taste in the mouth in 15 to 20 seconds on most occasions. Thereafter, the patient notices a "cool sensation" in the hands and feet which is followed within five minutes by a perceptible increase in skin temperature. There is an incomplete dilation of the pupil with some loss of accommodation. Shortly after the injection (approximately one minute), systolic and diastolic blood pressures tend to fall, particularly in the hypertensive patient. This fall in blood pressure is accompanied by an increase in pulse rate to between 90 and 120 beats per minute. Sweating, if present, ceases and the patient may become aware of a dry mouth. The vasoconstrictor gradient present in the extremities is largely abolished so that toe and thigh temperatures are equalized (Figs 1 and 2). The blood pressure gradually increases to the initial level although postural hypotension may exist for 15 to 60 minutes.

RESULTS OF BLOCKING THE AUTONOMIC GANGLIA WITH TETRAETHYLAMMONIUM BROMIDE

1 *Functional Vascular Disorders*—Some sixteen patients were studied with functional angiospastic disorders. Eight of these patients had Raynaud's phenomena alone or in association with other disorders, four patients had functional disorders such as acrocyanosis and livedo reticularis, and four patients had Raynaud's phenomena in association with scleroderma.

In this group, the functional response to tetraethylammonium was usually quite marked, a substantial rise in skin temperature and alleviation of at least a part of the clinical picture being the usual sequelae (Fig 1).

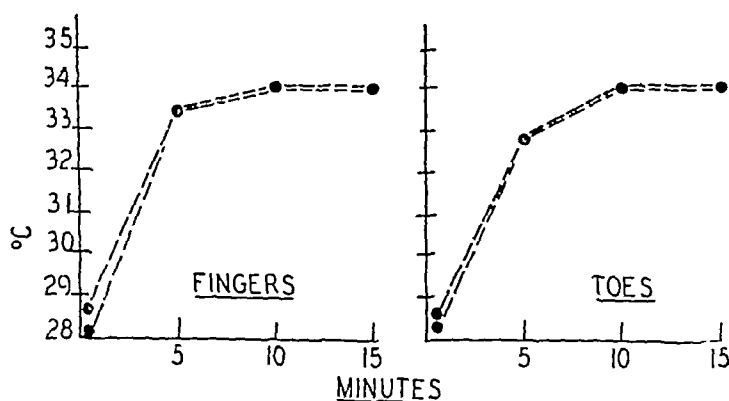


Fig 1—Peripheral skin temperature response in a patient with Raynaud's phenomena following the intravenous injection of 500 mg tetraethylammonium bromide. Patient subsequently developed disseminated lupus. Smoking did not alter the skin temperature readings.

There was a marked variation in the duration of the response to autonomic ganglia blockade in this group with functional disorders. For the most part, the drug served three useful purposes in these patients: (1) it obviated the necessity of single or multiple paravertebral blocks, particularly for the upper

extremity, (2) it was helpful in establishing the presence of a functional vascular component, particularly in the patients with scleroderma, (3) it was exceedingly helpful in aiding the establishment of a diagnosis.

The following case report is that of a patient with fulminating Raynaud's disease, who received intensive daily therapy in an attempt to ameliorate impending gangrene.

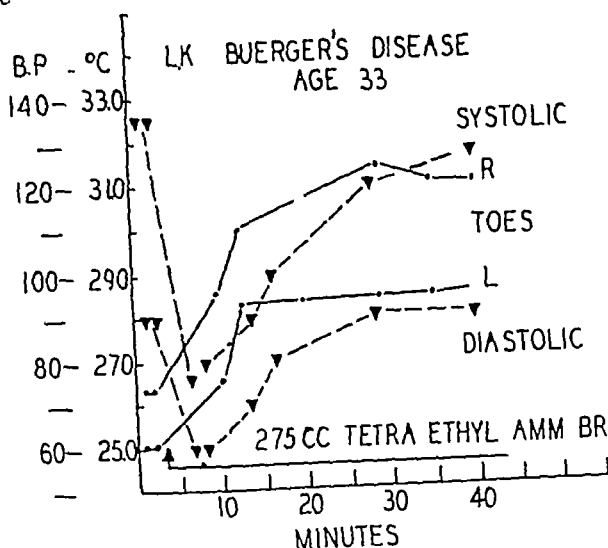


Fig 2—The effect on blood pressure and peripheral skin temperature of blocking the autonomic ganglia with 275 mg of tetraethylammonium bromide in a patient with thromboangiitis obliterans. The left leg had advanced occlusive changes. Superficial phlebitis was present in the right leg.

CASE REPORT

M T (No 236753), aged 30 years, a white woman, was admitted May 21, 1946, with the chief complaint of cold, blue, painful fingers and superficial gangrene of distal phalanges of the fourth right and third left fingers of nine days' duration. There were no previous similar attacks. On May 12, 1946, there was an onset of blanching (syncope), numbness and tingling, cyanosis and paroxysmal attacks of severe pain in symmetrical fingers of both hands. A strong suspicion of initial psychic trauma in the history was entertained but could not be elicited from the patient. There was a known fluctuation of blood pressure with the patient's paroxysms of pain. No petechial manifestations had been observed.

Examination revealed a blood pressure of 112/70. The patient was a highly excited woman in obvious distress. The hands were cold, cyanotic, and moist, and reticular blotching extended onto the forearms. The phalangeal joint areas were mildly edematous with some restriction of motion (35 per cent). There was superficial gangrene of the fourth right and third left finger tips. There was marked cyanosis of the entire distal two phalanges of the index and fifth fingers bilaterally.

Tetraethylammonium bromide, 500 mg intravenously, was administered with the following results: the cyanotic areas became red and warm. The patient was able to flex the fingers without restriction in approximately fifteen minutes. The reticular mottling disappeared. Skin temperature changes were as follows:

	RIGHT	LEFT
Thumb	31.4 33.0° C	29.8 32.0° C
Index	30.5 33.0° C	28.5 31.5° C
Third	31.5 33.5° C	29.0 29.0° C (gangrene)
Fourth	29.2 30.4° C (gangrene)	30.4 33.0° C
Fifth	28.9 30.0° C	30.2 32.8° C

Chest roentgenograms, detailed views of the cervical spine, electrocardiogram, blood cultures, blood studies, etc., were negative with the exception of a previously known rotoscoliosis

Repeated daily intravenous injections of tetraethylammonium were given to produce a sympathetic block, with gradual abatement of the fulminating Raynaud's syndrome, improvement in color, relief of pain, and arrest of further gangrenous changes. Bilateral dorsal sympathectomy was then performed on May 31, 1946, with the hope that further recurrences would be less likely to occur. Convalescence was uneventful.

2 Organic Obstructive Vascular Lesions—We have had the opportunity of studying the effects of tetraethylammonium bromide in some eighteen patients with thromboangitis obliterans and some fifty-five patients with all stages of peripheral arteriosclerosis obliterans. Of the patients with Buerger's disease, eleven have been treated conservatively over periods varying from two weeks to six months, three patients have had sympathectomy performed, one patient had a supracondylar amputation for moist gangrene (patient untreated except for diagnostic test), and three patients received only a single injection for the purpose of producing a sympathetic block. Of these three latter cases, all will be carried on a conservative regimen. Of the eleven patients treated conservatively including repeated sympathetic blocks by tetraethylammonium, five are symptom free including practical absence of previously existing intermittent claudication. Exercise tolerance has improved in all of this group. In the remaining nine patients in the group being treated conservatively, there has been a similar satisfactory decrudescence of clinical signs and symptoms, but this group has had only a relatively brief period of treatment (four to eight weeks). Three patients with thromboangitis obliterans presented themselves in the clinic initially with active superficial migratory phlebitis. These patients were hospitalized for brief periods (three days) during which time they received either repeated autonomic ganglion blockade (intravenous and intramuscular) daily, or daily blocks by the intravenous route. In all instances there appeared to be a satisfactory subsidence of the active inflammatory process. It is realized, of course, that similar changes might have occurred during bed rest without additional therapy. It is interesting to note, however, that none of these patients in this group have had a recurrence of the phlebitis to date (Fig 2).

TABLE II. CONTROL OF PAIN AND PREDICTED RESPONSE TO SYMPATHECTOMY
L. RU, AGED 36, BUEYER'S DISEASE*

TIME		DOSE	DURATION RELIEF		HOURS
2 30 P.M.		200 mg i.v.	6 45 P.M.		3+
12 10 A.M.		300 mg i.v.	1 30 A.M.		1+
2 25 P.M.		250 mg i.v.	8 00 A.M.		17+
2 Stage Bilateral Lumbar Sympathectomy and Right Sural Neurectomy					
TETRAETHYLAMMONIUM BROMIDE			RESPONSE		
			SYMPATHECTOMY		
Thigh	34 0	34 0	Thigh	32 0	32 4
Calf	33 2	32 5	Calf	32 3	31 4
Toe	30 0	30 0	Toe	30 1	30 1
Complete Pain Relief					

*Control of pain and predicted thermal response to sympathectomy in a patient with thromboangitis obliterans and severe intractable pedal pain of two years' duration especially nocturnal and predominantly on the right. The lower columns of figures correspond to right and left thigh, calf and toes respectively.

The following case histories are examples of the response to tetraethylammonium bromide exhibited by three patients with thromboangitis obliterans. One of these patients has been followed for eight months (C N), one for 5 months (L Ro) and one patient (L Ru) had a bilateral sympathectomy performed (Table II)

CASE REPORTS

L Ro (No 469585), aged 29 years, Hungarian Jew, was admitted March 22, 1946, with a two months' history of intermittent claudication, numbness and tingling in right foot and calf, and nocturnal foot pain. The patient had smoked one package of cigarettes daily for twelve years. Examination revealed slight pallor of the right foot on elevation. Vessel pulsations were present (weakly) peripherally. The right foot was colder than the left and a marked temperature gradient was measurable. Tetraethylammonium bromide, 500 mg, was injected intravenously, following which the numbness and tingling promptly disappeared (fifteen minutes). There was a 5°C rise in skin temperature of the toes. He returned April 5, 1946, stating that pain has ceased and the intermittent claudication was less severe. He had ceased smoking. Thereafter at weekly intervals he received autonomic ganglia blocks with tetraethylammonium bromide and continued to show progressive improvement. A right paravertebral sympathetic block with procaine demonstrated an excellent functional response comparable to that produced by the drug. On May 11, 1946, claudication had practically ceased and the patient was under full time employment. A total of seven sympathetic blocks at weekly intervals using tetraethylammonium was given. This represented a total dose of 3,500 mg. The patient has remained symptom free on repeated examinations.

C N (No 187333), aged 43 years, a white man, was admitted Feb 4, 1946, with a six year history of recurrent superficial migratory phlebitis of both legs. The patient had experienced progressive intermittent claudication for four years. Cold weather aggravated the complaints. Nocturnal pain was frequently present. Examination revealed typical acute saphenous phlebitis on the right calf. Posterior tibial and dorsalis pedis pulses were absent bilaterally. X ray examination of the legs and feet revealed no arterial calcification. Tetraethylammonium bromide, 500 mg intravenously, produced a 4°C rise in skin temperature of the toes and the patient stated that following this procedure, the legs felt normal for the first time in years. He returned Feb 7, 1946, stating that the claudication had greatly improved and the nocturnal pain had remained absent. The phlebitic process showed evidence of subsidence. He received 12 Gm. of the drug intramuscularly and returned on Feb 8, 1946. At this time, pulses were weakly palpable bilaterally at the ankle. He again received 10 Gm. tetraethylammonium intramuscularly and was instructed to return in two weeks at which time the therapy was repeated. The only residual of the phlebitic process was a cord like area of nonpainful induration. He returned one month later on April 4, 1946, able to walk three blocks without claudication. This was farther than he had been able to walk in several years. The total dose of tetraethylammonium administered was 4,700 mg.

Peripheral arteriosclerosis obliterans. Fifty-five patients with clinical signs and symptoms of peripheral arteriosclerosis obliterans have been studied, utilizing tetraethylammonium bromide as a diagnostic, prognostic, and therapeutic measure. The drug has proved useful in two respects in these patients (1) aiding in the control of nocturnal pain, and (2) as an index of the possible benefits that might be derived from a lumbar sympathectomy*.

Early in the course of study of tetraethylammonium bromide, it was noted that in some of the patients with arteriosclerosis obliterans, who were complaining bitterly of nocturnal pain, that relief was experienced following the intra-

*Subject of separate report.

venous or intramuscular injection of tetraethylammonium bromide. This relief occurred whether or not a functional component was demonstrable, that is, the relief occurred despite the absence or presence of vasospasm, and the nocturnal pain returned only if the injections of the drug were discontinued. Several of these patients claimed relief of pain superior to that obtained from morphine.

The following case history is illustrative of the use of tetraethylammonium in the study and therapy of peripheral arteriosclerosis obliterans.

CASE REPORT

H C (No 585004), aged 62 years, a white man, was admitted Feb 4, 1946, with a nine month history of intermittent claudication in the right calf. Several months previous to admission, a saphenous ligation had been performed elsewhere for supposed varices. Following this procedure, pain and discoloration of the foot appeared and a 4 by 4 inch area of dry gangrene on the dorsum of the foot subsequently developed. There was a three months' history of constant pain in this foot, especially at night. Examination revealed far advanced occlusive peripheral arteriosclerosis. Tetraethylammonium bromide intravenously demonstrated a small functional component to be present, a 1.5° C rise in skin temperature being the maximal response. The patient experienced relief of the nocturnal pain following the administration of the drug, and was accordingly treated with repeated intramuscular injections of tetraethylammonium bromide, 5,000 mg given in divided doses. When this therapy was withdrawn, the nocturnal pain recurred. No improvement in the gangrenous slough occurred and, accordingly, a right supracondylar amputation was carried out on Feb 25, 1946. He recovered satisfactorily. It was felt that the wisest procedure, as a prophylactic measure, would be to perform a left lumbar sympathectomy as a protective measure for the remaining weight bearing extremity. This was carried out on March 7, 1946. Follow up report on June 7, 1946, showed the patient to be in good condition. The predicted thermal response to sympathectomy as judged by response to tetraethylammonium bromide was exact.

3 Causalgic Disorders and Reflex Sympathetic Dystrophies—Some seventeen patients with a diagnosis of causalgia, posttraumatic edema, or reflex sympathetic dystrophy have been studied utilizing tetraethylammonium bromide. The choice of terminology for diagnosis in some of these patients was quite difficult. These disorders occurred as the result of old fractures with prolonged immobilization, gunshot wounds with associated nerve palsy, delayed postoperative edema of the arm with and without intractable pain, fibrositis, peri-arthritis and Sudeck's atrophy, cervical rib with vasospasm, healed chronic infection of the fascial spaces, postimmersion and trench foot sequelae, old trauma, etc.

The injection of tetraethylammonium in these patients served three useful purposes: (1) it usually afforded temporary and at times sustained relief of pain, (2) it aided in establishing the diagnosis of reflex dystrophy, (3) it was highly effective as a therapeutic measure in selected cases.

The following case report is illustrative of the use of tetraethylammonium bromide in producing autonomic ganglion blockade in this group of patients.

CASE REPORT

D L (No 588735), aged 54 years, a white woman, was admitted April 29, 1946, with a history of having sustained a fracture of the left humerus on Nov 17, 1945, which had been treated with a hanging cast. Examination revealed a typical reflex sympathetic dystrophy, periarthritic fibrositis, and Sudeck's type atrophy with a painful, hypersensitive left upper

extremity The left hand was cool and moist with periarthritic changes and moderate edema. Injection intravenously of 350 mg tetraethylammonium bromide produced an excellent autonomic block with a 4°C rise in temperature of the digits. She was again seen and treated on April 30, 1946, there having been some improvement in range of motion of the fingers. On May 1, 1946, a third injection was given and examination at this time revealed a practically normal range of motion of all joints in the left upper extremity. All pain had disappeared with exception of pain in the shoulder girdle. Despite this, the patient was able to elevate the hand above the head for the first time in months. On May 2, 1946, a fourth injection of the drug was given and the patient reported complete freedom from pain. Thereafter, she was followed at frequent intervals until May 28, 1946, at which time improvement was felt to be maximal. A total dose of 7,200 mg of tetraethylammonium bromide was given this patient.

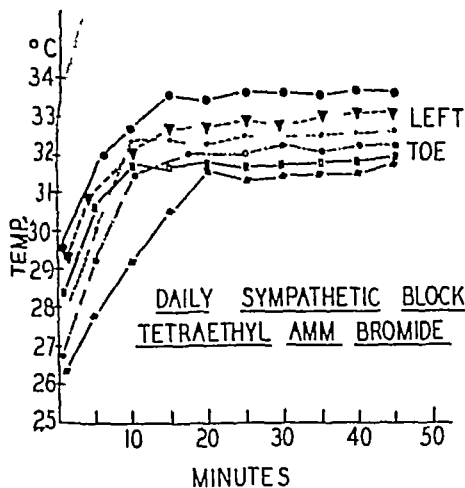


Fig 3 (T E.)—Response to daily autonomic ganglion blockade in a patient with progressive iliofemoral thrombophlebitis of the left lower extremity

4 Thrombophlebitis—Nine patients with superficial or deep thrombophlebitis have been treated with tetraethylammonium. All nine of these exhibited vasospasm in association with the primary disorder prior to treatment (hyperhidrosis, pain, mild cyanosis, coldness, demonstrable vasoconstriction). Six of the nine patients had either acute or chronic deep femoral thrombophlebitis. The three remaining patients had migratory phlebitis in association with thromboangitis obliterans.

Tetraethylammonium proved useful in two respects in this group of cases, (1) as a measure capable of releasing vasospasm by blocking the autonomic ganglia, and (2) as a therapeutic measure in the acute or active cases wherein daily blocks proved advantageous as a supplementary measure in therapy. The duration of effects was surprisingly variable, some patients reporting a period of several days in which the extremity remained warm and painless, while other patients experienced relief of symptoms for only a few hours.

The following case report is illustrative of the most striking response to tetraethylammonium in the group of patients with thrombophlebitis (Fig 3)

CASE REPORT

T E (No 584769), aged 31 years, a white man, was admitted Jan 6, 1946, with a history of having been in an automobile accident two months previously, at which time he

traumatized the lateral aspect of the left leg. Roentgenograms were reported as negative. Two weeks after the accident, the patient experienced sudden severe chest pain of a pleuritic nature followed shortly by prune juice sputum. This was diagnosed elsewhere as pneumonia despite a swollen, painful, left lower extremity. He had also experienced chills and fever. He was treated at that time with paravertebral sympathetic blocks, and had gradual abatement of the acute process. Upon returning home (Michigan), he experienced an acute exacerbation of the thrombophlebitic process with swelling, pain, and fever. Examination on Jan 6, 1946, revealed a moderately ill white man with gross ligament. Homan's sign was positive. There was calf and groin tenderness. Collateral venous tributaries were evident. The patient was hospitalized and received daily intravenous and intramuscular injections of tetraethylammonium bromide (Fig 3). There was rapid subsidence of the edema and within ten days the patient was afebrile, ambulatory, and free of significant edema. He was discharged on supportive measures. Careful bimonthly follow up reports state that the patient has remained asymptomatic and that he does not have significant edema.

UTILIZATION AS AN OUTPATIENT PROCEDURE

The intravenous injection of tetraethylammonium bromide to produce autonomic blockade has been utilized daily as an outpatient procedure for the past eight months. Following treatment, the patient is maintained in a horizontal position for at least 15 to 30 minutes. At the end of this time he is allowed to sit up and then stand up. If no dizziness or syncope occurs, or if postural hypotension is not marked, he is allowed to walk about the clinic for a few minutes and is instructed to lie down should he experience unpleasant symptoms. No emergency hospitalization following the administration of this drug has been necessitated at any time. The patient is asked to refrain from driving his car for one to two hours because of loss of accommodation. The patient is usually unaware of any visual impairment. Adrenalin is specific in counteracting any untoward symptoms.

TOXIC EFFECTS

In the doses used in this study and in the patients reported here, no significant toxic effects were noted. In other cases reported elsewhere,⁸ complications of the injection were experienced. Some patients with very high blood pressure experienced a state of peripheral circulatory collapse following the intravenous injection which was quite transient in character and which responded to epinephrine. Other patients had developed a state of dyspnea similar to that observed in hysterical hyperventilation. In a few patients the sensation of weakness, fatigue, and lightheadedness was very pronounced. They appear to experience difficulty with muscle movement, though when tested there was no loss of strength or change in reflexes. The drug has been administered more than 1,000 times to more than 500 patients in the doses indicated with very few alarming reactions.

SUMMARY

1 Clinical experience with tetraethylammonium (bromide or choride) has demonstrated its efficiency in producing blockade of the autonomic ganglia to a degree comparable to that obtained following the usually accepted methods of producing a sympathetic block.

2 A large and varied series of peripheral vascular and allied disorders have been studied utilizing this drug as a method of producing either a temporary or prolonged sympathetic block to improve circulation or ameliorate pain of circulatory origin. This drug has proved satisfactory in producing both of these desired results.

REFERENCES

- 1 Ochsner, A, and DeBakey, M. Peripheral Vascular Disease. A Critical Survey of Its Conservative and Radical Treatment, Surg, Gynec & Obst 70 1058 1072, 1940
- 2 Acheson, G H, and Moe, G K. Some Effects of Tetraethylammonium on the Mammary Heart, J Pharmacol and Exper Therap 84 189 195, 1945
- 3 Acheson, G H, and Moe, G K. The Action of Tetraethylammonium Ion on the Mammary Circulation, J Pharmacol and Exper Therap 87 220, 1946
- 4 Acheson, G H, and Pereira, S. The Blocking Effect of Tetraethylammonium Ion on the Superior Cervical Ganglion of the Cat, J Pharmacol. and Exper Therap 87 273, 1946
- 5 Lyons, R H, Moe, G K, Campbell, K N, Hoobler, S W, Neligh, R B, Berry, R L, and Rennich, B. The Effects of Blockade of the Autonomic Ganglia in Man. Preliminary Observations on the Use of Tetraethylammonium Bromide, Univ Hosp Bull, Ann Arbor 12 33, 1946
- 6 Lyons, R H, Moe, G K, Neligh, R B, Hoobler, S W, Campbell, K N, Berry, R L, and Rennich, B. The Effects of Blockade of the Autonomic Ganglia in Man With Tetraethylammonium. Preliminary Observations on Its Clinical Application, Am. J M Sc. In press
- 7 Ochsner, A, and DeBakey, M. Therapeutic Consideration of Thrombophlebitis and Phlebothrombosis, New England J Med 225 207 227, 1941
- 8 Scott, W J M, and Morton, J J. Sympathetic Activity in Certain Diseases, Especially Those of the Peripheral Circulation Arch Int Med 48 1065, 1931
- 9 White, J C. Diagnostic Blocking of the Sympathetic Nerves to Extremities With Procaine, J A.M.A 94 1382 1388, 1930
- 10 Trimble, R, Cheney, W S, and Moses, W R. The Operative Attack on Organic Peripheral Vascular Disease, SURGERY 15 655 678, 1944
- 11 Leriche, R, and Fontaine, R. Experimental and Clinical Contribution to the Question of Innervation of the Blood Vessels, Surg, Gynec & Obst 47 631 643, 1928
- 12 Grimson, K. S. Sympathectomy and the Circulation—Anatomic and Physiologic Considerations and Early and Late Limitations, SURGERY 19 277 298, 1946
- 13 Evans, J A. Reflex Sympathetic Dystrophy, Surg, Gynec & Obst 82 36-43, 1946
- 14 Coller, F A, and Maddock, W G. The Function of Peripheral Vasoconstriction, Ann. Surg 100 983 992, 1934
- 15 Ochsner, A. Indications and Technique for Interruption of Impulses Traversing the Lumbar Sympathetic Ganglia, S Clin. North America, pp 1318 1334, 1943

TREATMENT OF NONUNION OF THE CARPAL NAVICULAR BONE

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TREATMENT of nonunion of a fractured carpal navicular bone directed primarily to alleviate recurrent pains and swelling of the wrist is far from a solved problem, as is evidenced by lack of uniform good end results. The methods of treatment presently in use are those of excision of part or all of the fractured navicular bone, excision and replacement by vitalium replica, drilling, or bone grafting of the segments¹. The latter procedures, namely drilling or bone grafting, are designed to revascularize the necrotic or partly necrotic bone, the sclerotic borders, or the intervening fibrous barrier at the site of nonunion by granulation tissue derived in part from the contiguous living portion of the navicular bone. The success of either one of these two surgical methods depends primarily on the potential source of blood supply and the osteogenic tissue derived from the contiguous living fragment or fragments of the carpal navicular bone. When the blood supply from the contiguous fragments is inadequate, and this occasionally occurs, nonunion may result in spite of these surgical interventions. Excision of parts or of the entire fractured navicular bone results in some instances in weakness, pain, and loss of function in the wrist. This particular surgical treatment is, therefore, not generally advised.

Based on the observation that bone formation occurs frequently at the site of nonunion of a fractured femoral neck after a subtrochanteric osteotomy, a procedure employing a parallel idea was used in selected cases of nonunion of the fractured carpal navicular bone. Instead of an osteotomy, an arthrodesis between the fractured navicular bone and the capitate bone and curettage at the site of nonunion were performed in an attempt to obtain bony obliteration of the navicular capitate joint and simultaneous healing of the navicular bone (Fig 1). This procedure was done in four patients, in three of whom there was evident nonunion of the carpal navicular bone complicated by either relative sclerosis, resorption, or marginal exostoses and recurrent local pain and swelling. In the fourth patient, in an instance of simultaneous fractures of the right and left navicular bones, this procedure was performed in an attempt to abort a rapid progressive resorption and sclerosis of the surfaces at the site of non-union of one of the fractured navicular bones.

Three of these four patients had suffered from mild trauma to their wrists, ten months, two years, and four years before, respectively. None had received any previous medical attention for these injuries. With the pursuit of light work in civilian life, these three patients had only occasional attacks of local pain and swelling. After they had performed several months of routine military duties, it was noted that their wrists had become chronically enlarged and painful. In fact, they all reached a stage where they were unable to do any type

of work without experiencing pain in the carpal region. Furthermore, examination revealed that the normal landmarks of the wrists were obliterated by effusion and that tenderness was present on pressure over the fractured navicular bones. The fourth patient suffered from simultaneous fractures of the right and left carpal navicular bones following an injury sustained in a troop football game. In this case, immobilization of the right and left forearms, wrists, and thumbs in plaster of Paris bandages was followed for five successive months. This had resulted in complete healing of the right navicular bone and progressive resorption at the site of fracture with resultant sclerosis and nonunion of the left navicular bone. In this case and in the three previously mentioned, arthrodesis was performed between the navicular and capitate bones.

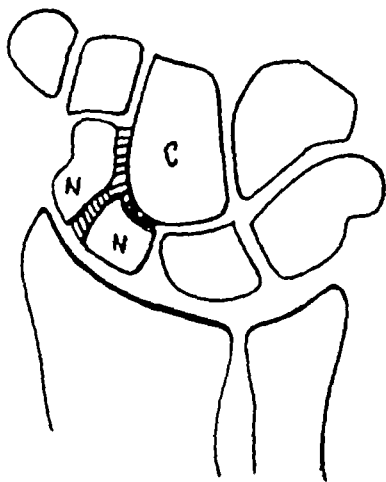


Fig 1.



Fig 2

Fig 1—Diagram of carpal bones of wrist. *N* is the fractured navicular bone. *C* is the capitate bone. The hatch lines indicate the site for the curettage and implantation of bone slivers.

Fig 2—Note scar on dorsum of hand as result of operation. This patient had an arthrodesis between an old ununited fracture of the navicular and capitate bones.

Technique of Operation—A horizontal incision measuring about two inches in length was made on the dorsum of the wrist in the region of the styloid process of the radius to a point in the vicinity of the distal radioulnar articulation (Fig 2). The long extensor tendon to the thumb and the common extensor tendons of the fingers were exposed and retracted to either side of the wound. The dorsal branch of the radial nerve was isolated and retracted. The

dorsal carpal ligament was incised in a cruciate fashion close to the insertion of the extensor carpi radialis brevis tendon in order to expose the joint space between the navicular and capitate bones. The contiguous articular cartilages of these two bones were removed to expose their subchondral regions. The site of nonunion of the navicular bone was thoroughly curetted to remove the sclerotic bone and the fibrous or granulation tissue. Slivers removed from the body of the capitate bone were placed in the navicular capitate joint space and into the curetted site of nonunion. The dorsal ligament of the wrist was loosely coapted and the tendons were repositied into their respective sheaths. The latter were closed with fine catgut and the skin was sutured with fine steel wire. A plaster of Paris bandage was applied to the forearm, wrist, and hand to the level of the interphalangeal joint of the thumb and necks of the metacarpals of the fingers holding the hand in 20 degrees of dorsiflexion and in maximal pronation. The plaster of Paris bandage was removed and reapplied every six weeks for a period ranging from five to six months following the operation.*

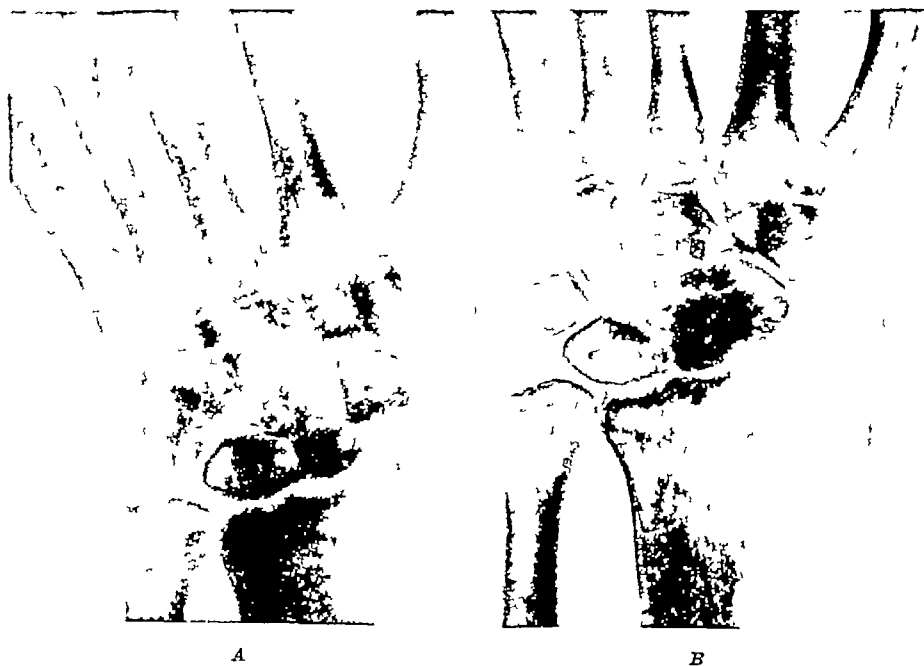


Fig 3—A, Radiograph revealing nonunion of the navicular bone with resorption of its surfaces at the fracture site (nonunion present for two years). B, Radiograph taken six months after the arthrodesis: note healing of the fractured navicular bone and fusion to the capitate bone.

Pre- and Postoperative Radiographic Findings—Preoperative radiographic examinations of the wrists of the four patients revealed definite evidence of nonunion of the navicular bone complicated by either relative increase in density of the proximal fragment, marked resorption or sclerosis of the margins at the

*It is of interest that in 1924 Thornton described a case of subluxation of the capitate bone which was treated by resection of its base and arthrodesis to its contiguous carpal bones.² No mention was made of treatment of a specific case of an ununited fractured navicular bone by this method.

site of nonunion, or the presence of marginal osteophytes. In three instances the postoperative radiographic examination revealed beginning union and fusion of the navicular bone to the capitate bone approximately four months after the surgical intervention. Radiographs taken from six to twelve months after the operation showed the presence of bone in the previously noted rarified lesions as well as demineralization of the sclerotic foci in the navicular bone. Healing of the fractured navicular bone as well as fusion of these fragments to the capitate bone was definitely present in the three subjects in periods varying from six to twelve months after the operation (Fig 3). In one case in which an interval of four years of nonunion existed prior to the operation, bony healing of the fractured navicular bone was still incomplete eight months after the surgical intervention.

Pathologic Findings—Microscopic examination of the tissue removed during the operative intervention revealed that the bone obtained from the dense or sclerotic areas was for the most part necrotic and that the rarified areas (pseudocysts) were filled with loose granulation tissue. Portions of the articular cartilages which were removed in the vicinity of the nonunion presented definite evidence of fibrillation and degeneration. In addition, in one instance irregular proliferation of new bone and cartilage was also observed which indicated the presence of a marginal osteophyte. Capsular tissue obtained from the navicular capitate articulation showed definite evidence of increased vascularization and hypercellularity of the synovial lining.

Follow-Up Observation—Follow-up examinations of the four patients from eight to twelve months after the arthrodesing operation revealed that the "annoying" pain and swelling probably due to a local synovitis which existed prior to the surgical intervention was now absent. Although the range of motion in the wrists was to a certain extent lessened as a result of the operation, the resultant power of the affected hands was definitely increased. In fact, these four patients are now doing some type of useful work in the Armed Forces where previously they were compelled because of local pain and swelling to limit the use of their hands (See Table I).

TABLE I RANGE OF MOTION AT THE WRISTS BEFORE AND SIX MONTHS AFTER OPERATION

CASE NUMBER	PREOPERATIVE RANGE OF MOTION OF HAND (IN DEGREES)					POSTOPERATIVE RANGE OF MOTION OF HAND (IN DEGREES)				
	ACTIVE DORSI FLEXION	PASSIVE DORSI FLEXION	ACTIVE PALMAR FLEXION	PASSIVE PALMAR FLEXION	TOTAL RADIAL AND ULNAR FLEXION	ACTIVE DORSI FLEXION	PASSIVE DORSI FLEXION	ACTIVE PALMAR FLEXION	PASSIVE PALMAR FLEXION	TOTAL RADIAL AND ULNAR FLEXION
1 Nonunion for 6 mo (bilateral fractures)	40	45	35	35	35	40	60	35	35	35
2 Nonunion for 10 mo	25	25	60	50	45	30	30	25	25	20
3 Nonunion for 2 yr	45	45	50	55	35	20	35	20	20	25
4 Nonunion for 4 yr	10	10	40	45	25	20	20	30	30	20

DISCUSSION

The suggested procedure is not indicated in every case of nonunion of a fractured carpal navicular bone. In most instances multiple drilling of the fragments or the insertion of an autogenous bone graft heals the nonunion of the navicular bone. Neither one of these two methods, however, has any immediate effect on an existing traumatic arthritis in the intercarpal region. Arthrodesis between the navicular and capitate bones is recommended in those instances where there is extensive resorption or sclerosis of one or both fragments or when marginal osteophytes about the navicular or capitate bones are observed, especially when complicated by recurrent effusion and pain in the carpal region. Intercarpal arthrodesis is also applicable in nonunion or old subluxations of any of the other carpal bones where similar clinical conditions are present.

The forementioned procedure permits the opening of numerous avenues into the contiguous marrow spaces of relatively normal bone for a new and additional source of blood supply. This enhances "creeping replacement," transformation of the pathologic bone to a viable state, and aids in the healing of the nonunion.

SUMMARY AND CONCLUSION

In each of three cases of nonunion of the navicular bone complicated by either marked sclerosis, resorption, or marginal osteophytes of the navicular bone, as well as by pain and local effusion, an arthrodesis was performed between the fractured carpal navicular bone and the capitate bone. In the fourth instance of bilateral fractures of the navicular bone this procedure was done to abort a progressive resorption of one of these bones. In three of these four patients healing of the fractured navicular bone and bony obliteration of the navicular capitate articulation were noted from six to twelve months after the operation. In one instance in which there was nonunion existent for four years prior to the operation, incomplete bony healing was still noted eight months after the operation. It is interesting that follow-up examination from six to twelve months after the operation disclosed that there was an absence of swelling and pain in the four wrists even after repeated use of the hands. Some loss of motion was observed in each of the four wrists as a result of the surgical intervention. This was, however, compensated by the definite gain of power in the affected wrists and hands.

REFERENCES

- 1 Davidson, Arthur, J., and Horwitz, M. Thomas. An Evaluation of Excision in the Treatment of Ununited Fracture of the Carpal Scaphoid (Navicular) Bone, *Ann. Surg.* 108: 291, 1938.
- Murray, G. Bone Graft for Non union of the Carpal Scaphoid, *Surg., Gynec. & Obst.* 60: 529, 1935.
- Waugh, R. L., and Reuling, L. Ununited Fractures of the Carpal Scaphoid, *Am. J. Surg.* 67: 184, 1945.
- 2 Thornton, Lawson. Old Dislocation of Os Magnum, *South. M. J.* 17: 430, 1924.

A NEW METHOD OF BONE PLATING

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THE management of a simple fracture of the shaft of bone is time-tested and universally accepted. In essence this consists of approximating the ends of the fragments and then immobilizing the limb. When open reduction is indicated and a plate is then required for continued apposition of fragments, the treatment is definitely found wanting. The rational in using a plate is to appose the two broken sections of the shaft and to immobilize them. Unfortunately, this has not been accomplished. The fragments have been apposed but immobilization has been impossible with any plate used in the past. Even by causing some degree of impaction the play of the broken ends of bone upon one another eventually results in a hiatus or space between the apposed fragments and healing is consequently delayed. This knowledge has made immobilization of the broken limb, through plaster or some other means, mandatory following the application of a plate. Immobilization to be effective must include the joints on *both ends* of the fracture. This in turn, over a period of time, results in atrophy of muscle, decalcification of bone, and stiffness of the joints. In fact the disuse atrophy with its concomitant discomfort may be more of a problem than the original fracture.

I have devised an "assembly" consisting of two metal plates which appose the fragments of a bone shaft and immobilize them. In addition, the application in the hands of a qualified surgeon is simple and does not require any complicated or expensive equipment. The effectiveness of this "assembly" is such that no subsequent immobilization in plaster is necessary and rapid weight-bearing is permitted.

These exemplary features were discussed in a previous communication†. However, some noteworthy changes have since been made in the nuts and bolts which fix the immobilizing plates. This has permitted a simplification of the operation and has reduced the operative time to such an extent that I feel justified in presenting these improvements in this paper.

The appearance of the Wenger plate assembly can be seen in Figs 1 to 7.

The operative technique used in applying the assembly consists of making an incision at the site of the fracture, and then aligning the fracture in anatomic reduction (see Fig 3). While this is held in position by an assistant, the front plate (slotted plate) is placed across the site of the fracture on the bone surface nearest the operator. Four bolts are inserted into the holes and nuts are fitted onto both sides of each bolt (see Fig 4). The two outer bolts are

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†Wenger, H. Leslie. Shaft Fracture Immobilization Without Plaster, *Am J Surg* 60: 382-383, 1944.

then securely tightened. The two inner bolts are left loose until the back or notched plate is slipped into position under the nuts (see Figs 5 and 6)

When the notched plate is inserted under the two inner nuts, these latter are tightened with the wrench and the immobilization is complete. The construction of the notched plate permits compensation for inaccuracies in the position of the bolt holes

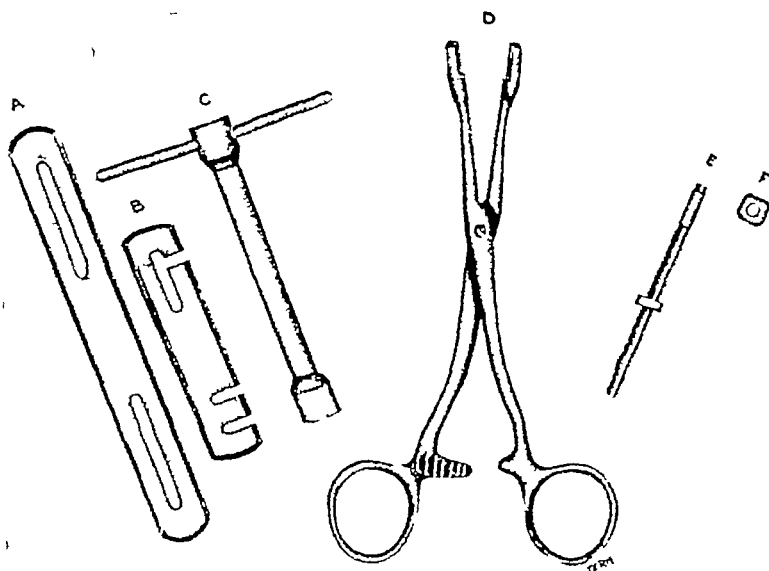


Fig 1—A and B are paired vitallium plates applied on opposite surfaces of the fractured bone. The larger plate (A) is known as the slotted plate and the smaller (B) as the notched plate. C is the wrench for tightening nuts. D is the clamp which holds the opposite nut firm so that the bolt does not turn and E is the bolt which is designed so that threads are at both ends and the threads on the far side of the bolt limit the nut on the bolt.

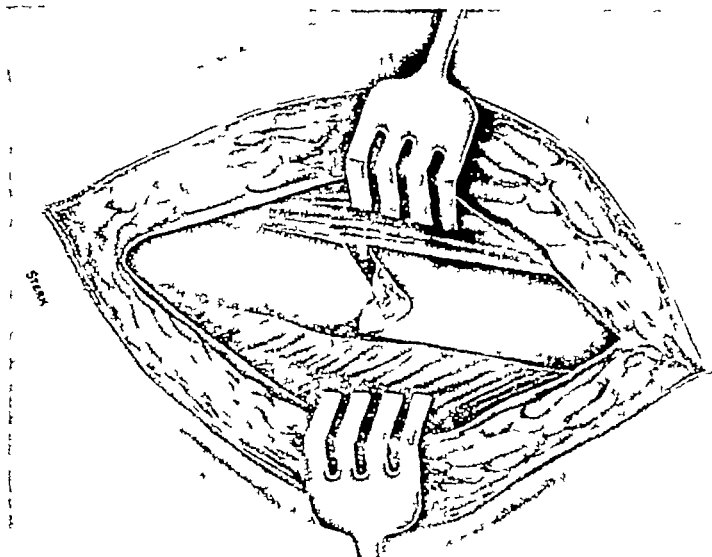


Fig 2—A shaft fracture with an operative exposure. The following Figs. 3 to 7 demonstrate the method of application of the assembly in situ of this fracture.

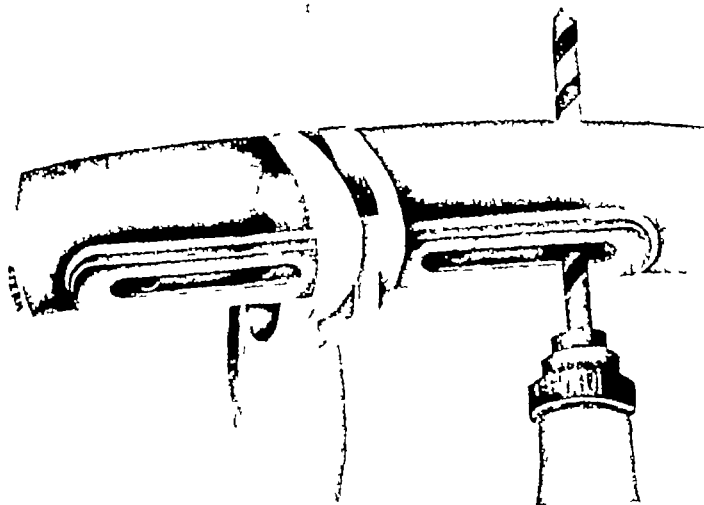


Fig 3—The fracture is reduced and held with a bone clamp. The slotted plate is in position and the four drill holes are in the process of being made

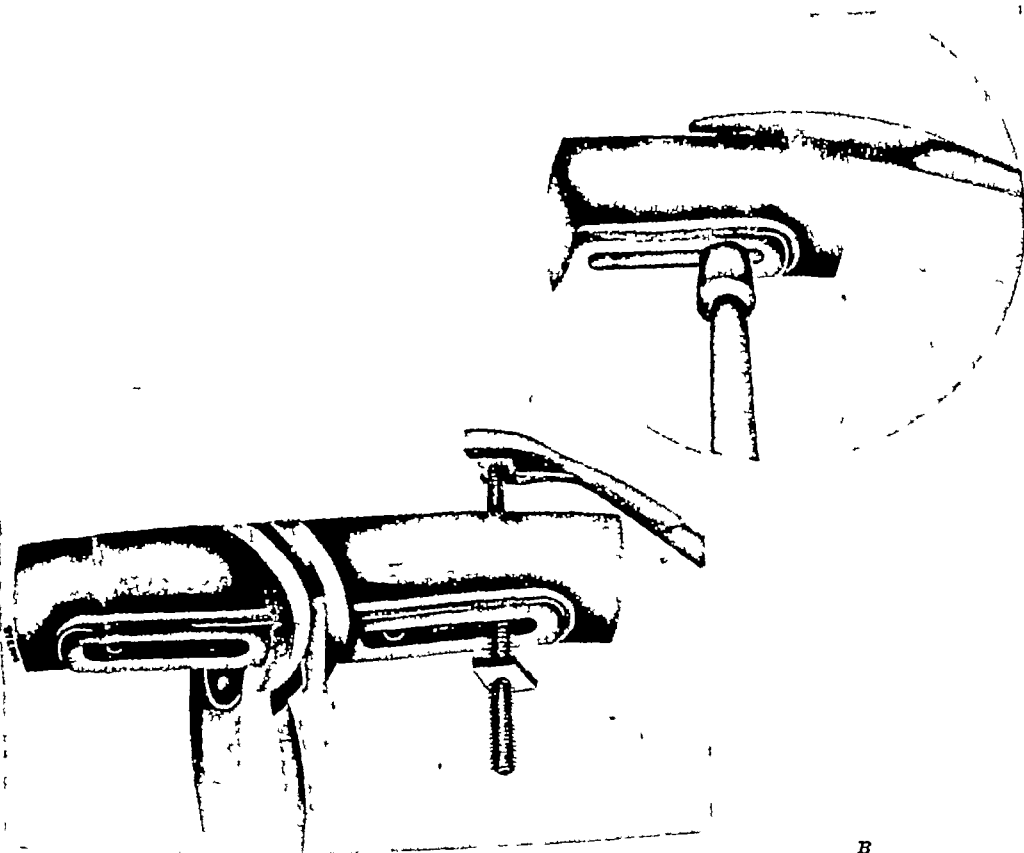


Fig 4—A, The bolts have been inserted through the holes (seen in Fig 3) and the nuts are fastened onto the farther end B, The method of tightening nuts is seen.

Excess length of bolt may be removed by means of cutting pliers with a high leverage factor

The periosteum on the bone should be left as intact as possible

The wound is closed in the routine fashion and a simple sterile dressing on the skin is used

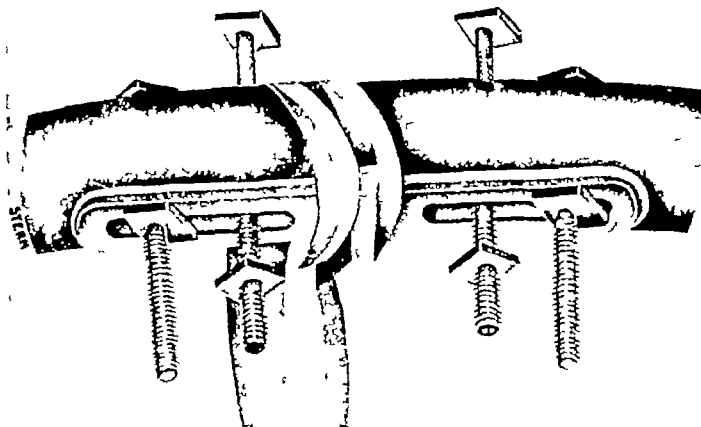


Fig 5—The remaining nuts are placed in position and the two end bolts are secured. At this stage of the operation the inner two bolts are left loose so that the smaller (notched) plate can be slid into position. Once this is done the inner nuts are tightened.

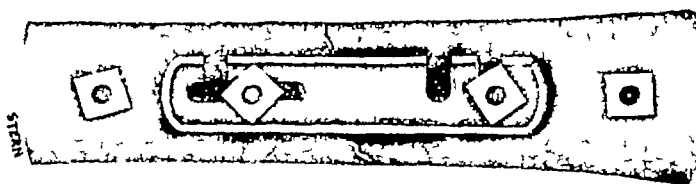


Fig 6—A view of the opposite side of the fracture is shown with the smaller notched plate in position and the nuts tightened.

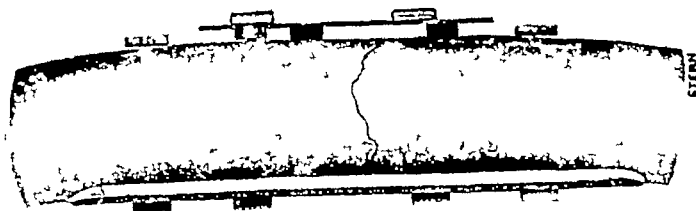


Fig 7—A lateral view of the fracture revealing both plates (the larger slotted and the smaller notched plate) in position and the fracture impacted.



Fig 8

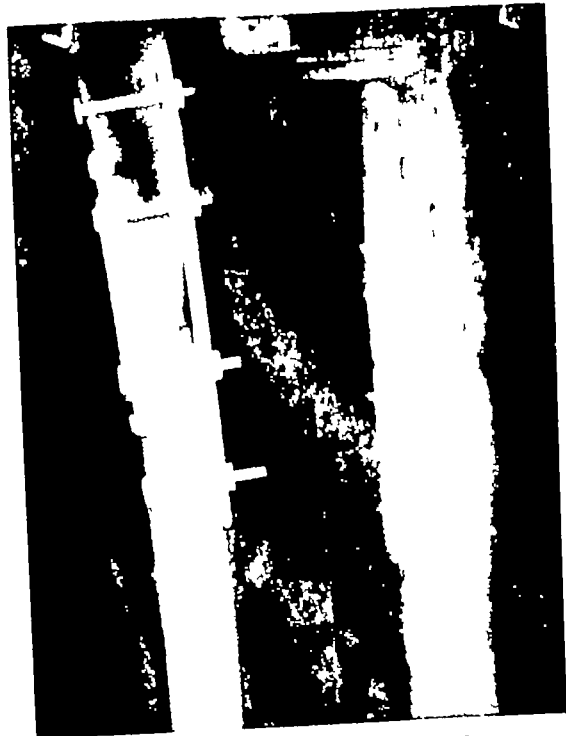


Fig 9

Fig 10

Fig 8—Patient was a 21-year-old boy who was in an automobile accident. Roentgenogram upon admission to the hospital revealed a transverse fracture of the shaft of the femur. A Thomas splint used in transit can be seen.

Fig 9—Postoperative x-ray view shows alignment of the fractured ends of the femur. The assembly is in situ. No plaster or other immobilizing measures have been used.

Fig 10—X-ray view taken two months postoperatively reveals profuse callus formation and excellent healing of the fracture.

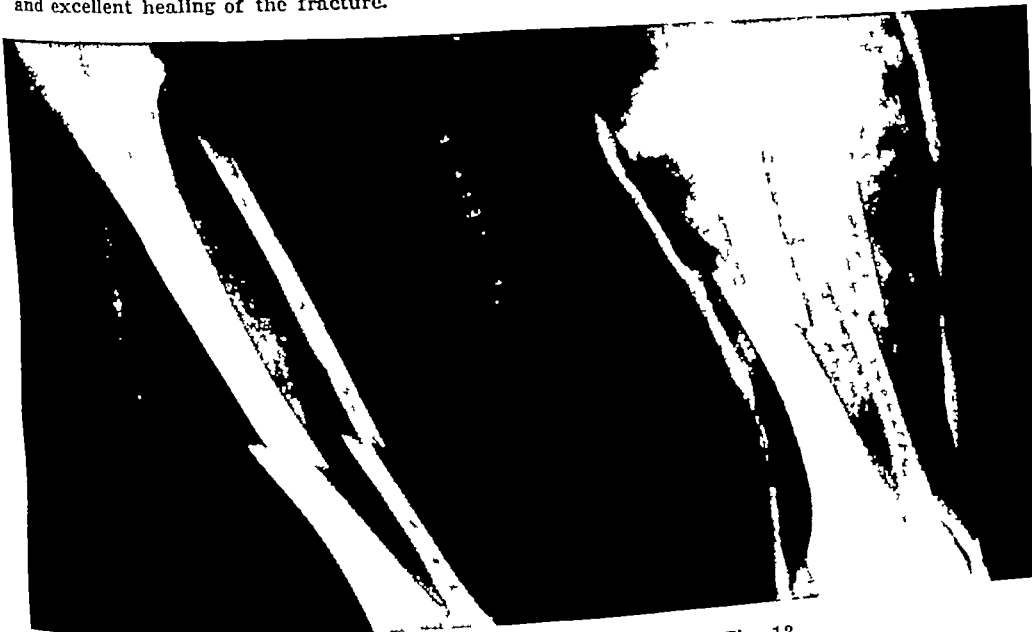


Fig 11

Fig 12

Fig 11—Patient was a 59-year-old white man who sustained a fracture of the left tibia and fibula when a pile of sheet glass collapsed upon his leg.

Fig 12—Closed reduction of the fracture was attempted followed by immobilization with plaster. After eight weeks the bone fragments were not well approximated and there was no callus formation.

The efficacy of the assembly in immobilizing a shaft fracture without the additional use of plaster or some other splinting aid is admirably demonstrated in the following two cases

CASE REPORTS

CASE 1—Patient D H was 21 years of age. He was struck by an automobile and sustained a fracture of the shaft of the femur (Fig 8). He was operated upon and the Wenger assembly was utilized (Fig 9). The following day the patient was able to move about in bed flexing the knee and hip without any discomfort.

On the fifth day the patient requested bathroom privileges, which were granted. There was actual weight bearing on that day although crutches were used and the patient continued to be ambulatory from that time on. Two months later x-ray examination (Fig 10) showed excellent healing of the fracture.



Fig 13

Fig 14

Fig 13.—An open reduction operation was performed. The Wenger apparatus was the sole form of immobilization. Good apposition of the bone fragments of the tibia was achieved.

Fig 14.—Follow-up x-ray picture six months after operation showing healing of both the tibia and fibula with callus formation, an excellent result.

CASE 2—Patient C A was a 59 year old white man. He sustained a fractured left tibia and fibula when a pile of sheet glass collapsed upon his leg (Fig 11). Closed reduction was attempted and the leg was immobilized in plaster. After eight weeks there was still no callus formation and the ends of the bones were not well approximated (Fig 12).

An open reduction was therefore performed and the fractured ends of the tibia were apposed. The Wenger apparatus was the sole form of immobilization used (Fig 13). Five days after operation the patient was able to walk and bear weight on the involved limb.

A roentgenogram taken six months later shows healing with callus formation of both the immobilized tibia and also the fibula (Fig 14). There was excellent function of the leg.

SUMMARY

1 A new method of bone plating of shaft fractures without subsequent plaster immobilization has been described

2 The advantages of this method are the ability to appose the fractured ends of bone and establish such a rigid fixation that no auxiliary measures of external immobilization (plaster, etc) are required This obviates disuse atrophy and other discomforts attendant upon nonfunction or disuse of not only the affected limb but the joints on both ends of the fracture The patients are ambulatory in a few days and healing changes are accelerated

3 Two cases are shown which demonstrate the efficacy and results of this method

CONGENITAL ESOPHAGEAL ATRESIA WITH TRACHEOESOPHAGEAL FISTULA

A CASE REPORT OF SUCCESSFUL END-TO-END ANASTOMOSIS

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LAM⁶ has recently summarized the literature on surgical correction of congenital atresia of the esophagus with tracheoesophageal fistula. While this anomaly is not rare (there are over 400 cases now on record) interest in the condition has recently received a stimulus from successful reports of operations for the once uniformly fatal lesion. In 1929, Vogt^{1,2} summarized the variations of this anomaly in the following classification which is still widely accepted: Type I, complete absence of the esophagus, extremely rare; Type II, blind end to both upper and lower segments of the esophagus, with no tracheal communication from either segment, rare; Type IIIa, upper segment with tracheal communication and a blind lower segment, rare; Type IIIb, a blind upper segment and a communication between the lower segment and the trachea, common type; Type IIIc, communication of trachea with both upper and lower segments, rare. Thus, there is only one frequent type, IIIb, comprising about 90 per cent of the cases.⁷ Inasmuch as all attempts at reconstructing a functional esophagus were failures until 1941,² and because so few successes have been reported since that time, the presentation of this single case seems justified.

The records of the University of Virginia Hospital reveal eight cases of this anomaly, the first having been diagnosed in 1932 (Table I). Each case falls into Vogt's^{1,2} type IIIb classification with a blind upper esophageal pouch, and the lower esophageal segment entering the trachea. The fact that five of the eight cases have been recorded in the last two years is perhaps due to a higher index of suspicion of the presence of such an anomaly in infants who present the classical syndrome. Attempts at curative surgery have been made in the five cases encountered since 1943, one patient having been operated upon elsewhere. The first two of our four attempts were made by employing the left transpleural approach. One patient (Case 4, Table I) survived a one-stage transthoracic ligation of the fistula and a cervical esophagostomy, but died eighteen days later with strangulation during a gastrostomy feeding. The regurgitation of milk proved the recanalization of the ligated fistula, which was not divided at the time of operation. This phenomenon has been reported by Ladd.⁵ In the last two cases the approach was by an extrapleural posterior mediastinotomy, one on the left and the other on the right. Only one operation, the last, has been successful.

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TABLE I CONGENITAL ATRESIA OF ESOPHAGUS WITH TRACHEOESOPHAGEAL FISTULA, SUMMARY OF CASES, UNIVERSITY OF VIRGINIA HOSPITAL

CASE NUMBER	YEAR	ASSOCIATED ANOMALIES	OPERATION	OUTCOME
1	1932	Meckel's diverticulum	Gastrostomy only	Died 44th day, of aspiration pneumonia
2	1937	Multiple, absent radius, imperforate anus, vesicovaginal fistula, supernumerary thumb, club hand	Gastrostomy only	Died 5th day, of aspiration pneumonia
3	1940	None	Gastrostomy only	Died 26th day, of aspiration pneumonia
4	1943	None	Preliminary gastrostomy, transpleural exploration (left) one day later, ligation of fistula, esophagus not suitable for anastomosis, exteriorization of upper pouch	Died 18th day postoperative, when ligated fistula recanalized and milk was aspirated during gastrostomy feeding
5	1943	None	Primary transpleural exploration (left), diffuse attachment of lower esophageal segment to trachea, not suitable for anastomosis	Died on operating table (shock?)
6	1943	None	Primary extrapleural mediastinotomy left, segments of esophagus exposed, suitable for anastomosis	Died on operating table, death soon after pleura tore with resultant pneumothorax
7	1944	Multiple, hemivertebrae and absence of one ear	Operation elsewhere, details not known	Died soon after operation
8	1945	None	Primary extrapleural mediastinotomy on right, ligation of fistula and end to end anastomosis	Uneventful postoperative course, alive and well six months after operation

CASE REPORT

J. R. (case 209834), a white female infant, was born at the University of Virginia Hospital on Jan. 21, 1945, after a normal pregnancy and a slightly prolonged labor. It was noticed at birth that there was much pharyngeal mucus which required aspiration, and a marked but temporary laryngeal stridor.

Physical examination after admission to the premature nursery revealed no abnormalities except for the small weight of 2,330 grams (5 pounds, 2 ounces). At twenty-four hours the child was started on equal parts of 5 per cent glucose and normal saline solution by mouth in very small amounts, and soon thereafter a special formula of lactic acid milk with amino acids was started. It was noticed at this time that with every feeding the child would regurgitate and become somewhat cyanotic. Because the child continued to vomit, everything by mouth was withheld on the third hospital day and an intravenous drip of 300 c.c. of Ringer's lactate solution was given. On the completion of this drip the formula was again started with repetition of choking and cyanosis.

Because of repeated regurgitation of everything taken by mouth, a small catheter was passed into the esophagus on the morning of the fourth hospital day (third day of life), and an obstruction was met about halfway down the length of the esophagus. The patient was taken to the x-ray department and 2 c.c. of iodized oil were injected into the esophagus by catheter. A complete atresia of the esophagus with a large bulbous upper segment extending as far down as the second dorsal vertebra was noted on fluoroscopy. Roentgeno-

grams confirmed the fluoroscopic findings and also showed a large amount of gas in the stomach and intestinal tract (Fig 1) There was no evidence of pneumonia.

A diagnosis of atresia of the upper portion of the esophagus with tracheoesophageal fistula of Vogt's type IIIb was made and the patient was prepared for immediate operation with an intravenous drip of 50 cc of $\frac{1}{4}$ molar sodium lactate and 250 cc of Ringer's lactate solution



Fig 1—Preoperative roentgenogram after the injection of iodized oil into the esophagus showing blind upper esophageal pouch normal lung fields and the gas-filled gastrointestinal tract.

Operation—On Jan. 24, 1945, the following operation was performed by one of us (M.L.W.) Under local infiltration anesthesia ($\frac{1}{2}$ per cent novocain) a 5 cm incision was made on the right side between the scapula and the spinous processes beginning at the second rib and extending to the sixth. The extracostal muscles were divided and the sacrospinalis was retracted. Vessels were ligated with fine black silk. The third, fourth, and fifth ribs were resected subperiosteally from the transverse processes anteriorly to a point about 1 cm beyond the angles of the ribs. The intercostal bundles were ligated with fine silk and divided. By blunt dissection the parietal pleura was separated from the endothoracic fascia posteriorly until the mediastinum was entered. The azygos vein was identified, doubly ligated with fine silk, and divided. The large upper blind pouch of the esophagus was easily identified and dissected free as was the lower segment also, since it extended almost to the upper segment. Although much smaller in diameter it appeared to have a lumen adequate for

anastomosis The lower segment was attached to the trachea about $\frac{1}{2}$ cm inferior to the upper segment. A tracheoesophageal fistula at this point was isolated, after transfixing ligatures were placed in the wall of the fistula close to the trachea, the fistula was divided, opening the lumen of the distal segment of the esophagus The lumen of the upper segment was entered by amputating the bulbous tip of the upper segment

At this point in the operation the lighted retractor which was holding the lung forward accidentally injured the parietal pleura and a sucking pneumothorax resulted An attempt was made to give oxygen under positive pressure, which was only partially successful Because of the violent respiratory movements, a small quantity of ether was administered by the



Fig 2—Roentgenogram on sixth postoperative day after the ingestion of iodized oil The oil passed into the stomach very rapidly and did not outline the esophagus. A moderate pneumonitis persists in the right upper lobe adjacent to the field of operation.

open drop method, but this was soon discontinued because of cyanosis Since the hole in the parietal pleura was so large that it could not be repaired, a sponge was placed over the defect and the retractor reapplied After about five minutes the respiration became quiet and regular and the child's condition permitted resumption of the operation

A No 8 French urethral catheter was passed into the stomach through the distal segment of the esophagus, and its upper end was passed through the upper segment into the pharynx where it was retrieved by the anesthetist. The two ends of the esophagus could then be brought together over the catheter and held by traction sutures. With interrupted

very fine silk sutures the first layer of the anastomosis was placed, approximating the thick mucosa of the upper segment to the full thickness of the thin walled lower segment. A second row of similar sutures approximated the muscularis of the upper segment to the muscularis of the lower segment about 3 mm distal to the first line of sutures. This row tended to telescope the lower segment into the upper segment. After an apparently satisfactory closure the catheter was removed through the mouth.

Sulfanilamide crystals were scattered through the wound, which was closed in layers with interrupted silk sutures, leaving a small catheter in the pleural space through the accidental pleural defect. After the skin had been closed, a small amount of air was aspirated from the pleural space and 20,000 units of penicillin were injected. The catheter was then removed, leaving no drain there or in the mediastinum.

During the operation, 5 per cent glucose and a transfusion of 50 c.c. of whole blood were administered through a scalp vein. The infant's condition at the conclusion of the operation was fairly good in spite of the long tedious procedure and the fact that the pleural space was inadvertently widely opened. There was mild cyanosis on return to the nursery.



Fig. 3—Patient two and one-half months after operation. Weight 11 pounds, $\frac{1}{4}$ ounce.

Postoperative Course—The patient was kept in an oxygen tent in a head down position for four days and given 3,000 units of penicillin intramuscularly every three hours for three weeks.

At first nothing was allowed by mouth, and the child was maintained intravenously with sodium lactate, 5 per cent glucose, 5 per cent amino acid* solution and citrated whole blood until the fourth postoperative day. At this time 2 c.c. of equal parts of 5 per cent glucose and normal saline solution were given by mouth and repeated at two hourly intervals. On the sixth postoperative day the same amount of 5 per cent amino acid solution

*Mead Johnson's Amigen was the source of the amino acids. It consists of 5 per cent amino acids in a 5 per cent glucose solution with 0.2 per cent sodium chloride.

was substituted for the normal saline solution. The patient took these first feedings so well that on the ninth postoperative day she could be started on a special lactic acid formula* with the addition of amino acids. Thereafter, the patient's intake was gradually increased and she took the feedings without difficulty. During this time the child was given blood transfusions of 50 to 60 c.c. every other day. A part of the needed fluid was given in the form of 5 per cent amino acid solution intravenously.



Fig. 4—Roentgenogram two and one-half months after operation. Barium was used as the contrast medium. The esophagus appears normal. The lungs are clear and the resected ribs have regenerated.

On the day following operation, moderate edema was noted which for about six days gradually increased with corresponding gain in weight. On the twelfth postoperative day the patient began to lose weight and did so for six days, at which time all the edema had disappeared. At this time weight began to increase steadily at a normal rate and continued to do so until her discharge from the hospital.

The extrapleural wound space was aspirated with a hypodermic needle daily for the first five postoperative days, yielding an average of 10 to 15 c.c. of serosanguineous fluid, cultures of which were consistently negative. On the fifth day only 2 c.c. were obtained. Penicillin (10,000 units) was injected into the wound space after each aspiration.

*The special lactic acid milk formula consists of 16 ounces of whole cow's milk with only 2 per cent fat, 1 ounce of Cartose, 1 dram of lactic acid and 1 ounce of Amigen. This gives a formula of 25 calories per ounce.

On the third postoperative day the patient was fluoroscoped after the injection of 2 c c of iodized oil into the esophagus. After a brief delay at the site of the anastomosis, the iodized oil readily passed into the stomach (Fig 2). Repeated x ray examinations with iodized oil were made during the next two weeks, and at no time was any leakage around the anastomosis or any significant stricture seen. Except for a minor upper respiratory infection and a mild diarrhea for two days in the latter part of the hospitalization, the patient's course after the first two weeks of life was uneventful.

The patient was discharged on the forty fourth hospital day, thirty nine days after operation, in excellent condition and weighing 2,930 grams, a gain of 600 grams over the birth weight. She has been followed in the outpatient department at intervals of two weeks for nine months, and has a normal curve of weight gain. At no time has there been any difficulty in swallowing or any regurgitation. On April 4, 1945, approximately two and one-half months after operation, the child appeared well nourished (Fig 3) and barium studies of the esophagus revealed a normal appearance with no evidence of stricture (Fig 4). On May 16, 1945, the patient weighed 11 pounds and $\frac{1}{4}$ ounce. On Oct 15, 1945, nine months after operation, the child was in excellent health, weighed 16 pounds and $4\frac{1}{2}$ ounces, and showed entirely normal development.

COMMENT

The diagnosis in the case reported was suspected when the child began to vomit her food immediately after ingestion, and in the intervals to eject continually a small amount of foamy saliva. Cyanosis, especially at feeding time, was also a noteworthy symptom. These are classical signs of the type IIIb tracheoesophageal fistula. A small rubber catheter passed into the esophagus revealed an obstruction. A diagnosis of atresia of the esophagus was then fairly obvious and needed only confirmation by x-ray.

Contributions to the development of the surgery of this anomaly by Haight and Towsley^{2, 3} deserve the utmost credit. Haight not only performed the first successful anastomosis (1941), but also has operated in six of the thirteen successful cases now recorded in the literature.^{1-6 11} The indirect method of surgical attack (ligation of the fistula, gastrostomy, and cervical esophagostomy, planning the eventual formation of an antethoracic esophagus) was first successfully performed in 1940 by Leven⁸ and one day later by Ladd.⁵ Nineteen patients have survived this method of attack although the antethoracic esophagus has not been completed in all.^{4-6 8, 9} It is important to note that 70.8 per cent of the twenty-four patients operated upon by Haight³ had a morphology suitable for end-to-end anastomosis, and that all six of the surviving patients had this type of operation. Nine of eleven surviving patients reported by Ladd⁵ have had the long and complicated indirect method of attack.

There would seem to be no difficulty in choosing between the one-stage direct anastomosis and the indirect method from the point of view of functional end results. With the former, the patient has, following a single procedure, an esophagus approximating the normal, with the latter, he has, after a prolonged convalescence marked by multiple plastic operations, only a substitute for an esophagus. The data are as yet too incomplete to permit any positive conclusions on the relative operative risk of the two primary procedures. In our judgment there is only one reason for the indirect approach, namely, an anatomic condition

that will not permit direct anastomosis, which, unfortunately, is frequently encountered. The parents of one of our patients requested that no procedure be carried out if a direct anastomosis should prove impossible.

The operative technique of Haight³ was followed closely in the case reported and needs no further comment. After having tried both the transpleural and the extrapleural approaches (Table I) we greatly prefer the latter and we find the attack easier on the right than on the left side. The telescopic method of anastomosis over a small catheter is easily performed in a suitable case.

One significant variation from previously published methods is the failure to place a drain at the site of anastomosis. It was felt that penicillin used locally in the extrapleural space might maintain asepsis in the region of the anastomosis and minimize, thereby, the danger of infection and breakdown of the anastomotic suture line. The closed extrapleural space was aspirated daily for five days and penicillin injected after each aspiration. In the absence of a drain a higher concentration of penicillin can be maintained in the threatened space than in the presence of a drain.* Lam⁶ has recently used penicillin both systemically and locally but drainage was carried out in his cases.

This case is believed to be the fourth recorded case which did not include a supplementary gastrostomy. Gastrostomy was required in three of Haight's³ six cases, and the procedure has been used in all of the other successful cases reported by various authors either as a preliminary operative procedure or because of leakage of the anastomosis, or stricture. When gastrostomy can be avoided, the postoperative course is transformed from a difficult feeding and nursing problem of indefinite duration into one of parenteral maintenance for a few days, followed permanently by normal oral feedings. Penicillin, by lessening the incidence of anastomotic leaks, will probably decrease the need for gastrostomy.

The three important points in the postoperative care are the prevention of infection, the control of body temperature, and the maintenance of nutrition. The two former points need no particular comment, being comprised of routine procedures for the premature nursery with the addition of intramuscular penicillin. However, nutrition will probably always present an individual and difficult problem.

Probably the most difficult part of the nutrition problem in these infants is the maintenance of fluid balance, which is, of course, intimately concerned with electrolyte balance. Haight³ has noted the frequent occurrence of generalized postoperative edema, which, localized in the anastomotic suture line, might well result in failure to heal and consequent leakage. Schemm²⁰ has shown that patients may be given large quantities of fluid with impunity if the intake of sodium ion is low. Although the generally accepted fluid requirement of newborn infants is taken to be from 2½ to 3 ounces per pound (165 to 200 cc per kilogram) per day with wide variations between individual patients, the patient

*This principle has been utilized in this hospital in the treatment of the pleural space following resection of the lung in a series of cases the report of which is in press.

reported upon here received only about $1\frac{1}{2}$ ounces per pound per day during the period of intravenous maintenance. In spite of this low fluid intake, edema promptly developed postoperatively. The most logical explanation would seem to be the sodium taken in the form of sodium lactate, Ringer's solution, and normal saline solution both before and after operation. Certainly the other common causes of edema, such as low serum protein, circulatory failure, and capillary damage from anoxia, did not seem to be factors in this case. The balance in the newborn infant between edema on the one hand and dehydration on the other is delicate enough without the added handicap of abnormal gastrointestinal function. The weight and the other clinical manifestations of fluid balance must be closely watched in these cases. Fluid can be given as normal sodium chloride, 5 per cent glucose, or 5 per cent amino acid according to nutritional needs. In our next case we plan to limit the sodium intake still further.

The necessity to prevent ketosis in these infants is obvious. All fluid which is not given to meet the electrolyte and protein needs is given in the form of 5 per cent glucose. If this amount of sugar is not sufficient to prevent ketosis, it can be given in mixed solutions of glucose with sodium chloride or with amino acids.

The administration of protein is essential both to prevent edema and tissue waste, and to promote wound healing. It must be remembered that these patients have been starved from birth until operation, a period of from one to many days. Since protein foods cannot be allowed by mouth for from six to ten days postoperatively, they may be without oral protein nitrogen intake for from ten to fourteen days or longer. The resulting nitrogen deficiency can be made up by the intravenous administration of amino acids supplemented by blood transfusions, and by early administration (sixth day) of amino acids by mouth. Ascorbic acid must also be given in doses of 100 mg daily to aid in wound healing.

We believe that postoperative maintenance by the intravenous route was a factor in the successful result in this case. A constant drip was used, employing the scalp veins. The rate of administration can be better controlled with a very slow drip for long periods of time. With this method there is also less chance of abscess formation or sterile necrosis, and because one drip a day is all that is necessary, the infant is not disturbed as frequently. There were no reactions following the intravenous use of amino acids.

In conclusion, we feel that there should be the closest cooperation between the thoracic surgeon and the pediatrician in the handling of these cases. Certainly intelligent attention to the metabolism postoperatively is as important in the recovery of these infants as is the technique of the operation.

SUMMARY

A case of congenital esophageal atresia with tracheoesophageal fistula has been presented. The details of the diagnosis, operation, and postoperative care have been discussed.

REFERENCES

- 1 Daniel, R A, Jr Congenital Atresia of the Esophagus With Tracheo esophageal Fistula, *Ann Surg* 120 764, 1944
- 2 Haight, C, and Towsley, H A Congenital Atresia of the Esophagus With Tracheo esophageal Fistula Extrapleural Ligation of Fistula and End to End Anastomosis of Esophageal Segments, *Surg Gynec & Obst* 76 672, 1943
- 3 Haight, C Congenital Atresia of the Esophagus With Tracheoesophageal Fistula Reconstruction of Esophageal Continuity by Primary Anastomosis, *Ann Surg* 120 623, 1944
- 4 Humphreys, G H The Surgical Treatment of Congenital Atresia of the Esophagus, *SURGERY* 15 801, 1944
- 5 Ladd, W E The Surgical Treatment of Esophageal Atresia and Tracheoesophageal Fistulas, *New England J Med* 230 625, 1944
- 6 Lam, C R The Surgical Treatment of Congenital Atresia of the Esophagus With Tracheo esophageal Fistula, *Quart Bull Indiana Univ M Center* 7 32, 1945
- 7 Lanman, T H Congenital Atresia of the Esophagus A Study of Thirty Two Cases, *Arch Surg* 41 1060, 1940
- 8 Leven, N L Congenital Atresia of the Esophagus With Tracheo esophageal Fistula Report of Successful Extrapleural Ligation of Fistulous Communication and Cervical Esophagostomy, *J Thoracic Surg* 10 648, 1941
- 9 Nettrour, W S Case Report of Broncho esophageal Fistula, *Pittsburg Medical Bulletin* 31 128, 1942
- 10 Schemm, F R High Fluid Intake in Management of Edema, Especially Cardiac Edema, Details and Basis of Regime, *Ann Int Med* 17 952, 1942
- 11 Shaw, R Personal communication quoted by Haight³
- 12 Vogt, E C Congenital Esophageal Atresia, *Am J Roentgenol* 22 463, 1929 .

TREATMENT OF ESOPHAGEAL ACHALASIA OR CARDIOSPASM

REPORT OF FOUR PATIENTS TREATED SURGICALLY

H MAX SCHIEBEL, M D , DURHAM, N C

DYSPHAGIA, retrosternal pain, and regurgitation of food are distressing and fearful symptoms for any patient to experience. The determination of the actual cause of such symptoms requires thorough investigation, and the humane aspect of therapeutic principles demands attention directed toward relief.

This symptom complex has been recognized for a long time and observations have been recorded as long ago as 1679¹. In that year a volume on *Pharmaceutice Rationalis* was published by Thomas Willis in which the following description is contained:

Of Vomiting

No less will a very rare case of a certain Man of Oxford shew, an almost perpetual Vomiting to be stirred up by the shutting up of the left Orifice. A strong Man, and otherwise healthful enough, labouring for a long time with often Vomiting, he was wont, very often, though not always, presently to cast up whatsoever he had eaten. At length the Disease having overcome all remedies, he was brought into that condition, that growing hungry he would eat until the Oesophagus was filled up to the Throat, in the mean time nothing sliding down into the Ventricle, he cast up raw (or crude) whatsoever he had taken when that no Medicines could help and he languished away for hunger, and every Day was in danger of Death, I prepared an instrument for him like a Rod, of a whale Bone, with a little round Button of Sponge fixed to the top of it, the sick Man having taken down meat and drink into his Throat, presently putting this down in the Oesophagus, he did thrust down into the Ventricle, its Orifice being opened, the Food which otherwise would have come back again, and by this means he hath daily taken his sustenance for fifteen Years and doth yet use the same Machine, and is yet alive, and well, who would otherwise perish for want of Food. Without doubt in this case the Mouth of the Stomach being always closed, either by a Tumour or Palsie, nothing could be admitted into the Ventricle unless it were violently opened.

In this very clear description we see not only a fairly complete account, but also an ingenious method of treatment which, with a few modifications, is still in common use. Again, in 1889, there appeared in the *Boston Medical and Surgical Journal* a description by Osgood² of six patients suffering from dysphagia.

The distress was always located beneath the xiphoid cartilage as high as its union with the gladiolus, and here tenderness on pressure is usual. From its point of origin the discomfort, which is very peculiar in character, may radiate up to the pharynx and from that locality pass into one or both ears. When the entire tract of the esophagus is thus involved the distress is very annoying and is apt to alarm the patient. There is the sense of impending suffocation. Sometimes the distress appears to the right of the median line and gradually involves the right chest as far as the outer border of the mamma, being sharply felt in the nipple. In extreme cases pain is felt in the back. At all times there existed difficulty in

swallowing beer, champagne, apollinaris water, and other gaseous drinks. As soon as the fluid reached the lower end of the esophagus a spasmodic, but only momentary, constriction followed. It is during the existence of an obstinate attack that the sufferer complains of a strange sensation of pain in one ear, very rarely both ears, and not at all in some cases.

Incidence—Achalasia is seen rather frequently and is second only to carcinoma as a cause of difficulty in swallowing. Guisez³ found that 17.4 per cent of 946 patients requiring esophagoscopic examinations for dysphagia or pain had achalasia. In Walton's⁴ series 17.8 per cent of all esophageal lesions were due to achalasia.

In 1904 Von Mikulicz⁵ collected 100 cases from the literature, and, by 1940, 1,200 cases had been reported by one group of workers.⁶

Symptoms—The symptoms consist primarily of pain, dysphagia, and regurgitation of food. Pain is present in 60 to 70 per cent of the cases in sharp contrast to the absence of pain in carcinoma. Also, in many instances solid foods can be taken as well as and sometimes even better than liquids. Cold drinks and cold foods are most poorly tolerated. One of my patients had been unable to eat ice cream for eleven years. Pain is not confined to periods of eating, but may appear at any time, even during the night. It is substernal, and may radiate into the cervical region, the angle of the jaw, and the mastoid region (Alvarez).⁷ In some instances it is also felt in the back at the level of the tenth to the twelfth thoracic vertebrae. Loss of weight is common. The vomitus sometimes comes immediately after eating or may not occur until night and only after several days. In milder instances the patient may get along without vomiting but will have to eat standing up, eating slowly and drinking warm fluids along with the meal. Periods of exacerbation may develop during which nothing can be taken for several days. These frequently correspond with emotional conflicts (Comby,⁸ Jacobson,⁹ Muggia,¹⁰ Bruhl,¹¹ Sudhues,¹² and Weiss¹³), but in some instances no such psychosomatic relation can be discovered. In certain cases what appears to be primary achalasia is aggravated by the fear of regurgitation so that the patient does reasonably well at home but is unable to eat in any public place or away from home. I have seen cases in which spasm was secondary to gall bladder disease, esophagitis, foreign body in the esophagus, peptic ulcer, and diaphragmatic hernia, and all these must be ruled out. Carcinoma must be differentiated. Clinically, carcinoma produces less discomfort and more gradual interference with swallowing, steadily progressive from solid foods to liquids.

Roentgenographic studies usually show a smooth, olive-tip type of obstruction at the cardia, with or without dilatation of the esophagus above. This may not be well outlined at first because of accumulated food in the esophagus. Esophagoscopic examinations may show considerable esophagitis secondary to retention of food.

Etiology—The etiologic factors responsible for the failure of the passage of solids and liquids through the junction of the esophagus and the stomach are probably many and varied, as evidenced by the numerous diagnostic names applied. These include cardiospasm, congenital dilatation of the esophagus,

phrenospasm, achalasia of the cardia, atony of the esophagus and megaesophagus, kinking of the esophagus, pressure from the left lobe of the liver, fibrosis of the periesophageal connective tissue, esophagectasia, and the ever-present idiopathic dilatation of the esophagus. The most recent addition has been "cardiospasm, a psychosomatic disorder"¹³

As in other branches of medicine, it is quite likely that this long list means either that the disease has many contributing factors or that the true agent has not yet been discovered. Rather complete discussions of causative agents are included in the articles of Ochsner and DeBakey,¹⁴ Schmidt,¹⁵ Heyrovsky,¹⁶ Vinson,¹⁷ and others. A very brief discussion will suffice to indicate these theoretical backgrounds and their resultant trends in therapy.

The congenital theory has had two groups of followers, those concerned with the main body of the esophagus, and those thinking in terms of the cardia. In 1897 Jaffie,¹⁸ thinking along the former line, suggested removing longitudinal ribbonlike strips from the wall of the dilated portion. This procedure was attempted, as well as simple pleating or plication of the wall longitudinally, without actual incision. Both attempts gave very poor results and were abandoned by 1911. Freeman,¹⁹ thinking in terms of congenital elongation rather than dilatation, advocated and carried out an artificial intussusception of the cervical portion into the midthoracic portion through a cervical incision.

More rational and also more numerous have been the procedures based on the theory of congenital spasm or stricture of the cardia. In 1899, Mikulez dilated the cardia by opening the stomach and inserting a finger up through the cardioesophageal junction. Later he devised an instrument for performing the dilatation through the invaginated anterior wall of the stomach, thus avoiding the contamination of the peritoneal cavity entailed in opening the stomach. It is interesting to note, however, that Heller²⁰ later reoperated upon two of these patients for the same condition. Obviously the cure was by no means permanent.

Although an operation similar to the Fredet-Rammstedt procedure had been suggested quite early, it was first performed by Heller in 1913. This was used by Heller twenty-one times by 1921, with the results reported as 80 per cent improved and 20 per cent poor. There was no mortality in his series, but in the hands of others the mortality has risen to 3.8 per cent in 104 cases collected by Ochsner and DeBakey with indifferent results or actual recurrences in about 19 per cent.

In 1910 Heyrovsky first performed an esophagogastrostomy, leaving the actual cardioesophageal junction undisturbed. This acted much as a spigot and results were greatly improved when Womack²¹ modified this in a fashion not unlike the Finney pyloroplasty.²² Haggstrom²³ reported twenty-nine patients successfully treated in this manner and others have been reported by Ochsner and DeBakey,¹⁴ Kredel,²⁴ Sprunt and Harrell,²⁵ and Wachs.²⁶ I have used this procedure, termed cardioesophagoplasty, in the four cases cited in this report. There are at present at least 115 patients treated in this manner, with five deaths, one poor result, and one only moderately improved. It is interesting that the one poor result and the mortality of five all occurred prior to 1938. The use of

sulfonamides and penicillin should continue to keep the present mortality figures low Kredel's²⁴ one patient had to have four dilatations about two months after the operation but was reported entirely well fourteen and one-half months later

Some mention must be made of the various procedures based upon neurogenic theories It is known anatomically that sympathetic fibers proceed to the esophagus from the inferior cervical ganglion and the celiac plexus⁵ Fibers from both vagi also enter it and it is because of these that a bolus of food in the esophagus initiates peristaltic action Section of these fibers alone does not produce cardiospasm In the follow-up examinations of the patients with peptic ulcer treated by transthoracic bilateral vagotomy about 6 to 8 cm above the diaphragm, no cases of cardiospasm or achalasia developed, although atony of the stomach did develop in all instances, in fact to an alarming degree in some²⁷

Experiments of Grondahl and Hanev²⁸ showed that in dogs achalasia would develop if the vagi were both cut 4 cm above the diaphragm and the esophageal muscle was divided down to the submucosa, but not if either one alone was performed Knight,^{29, 30} working with cats (the musculature of the esophagus in cats, apes, and man is composed of the same fiber types), in 1934, felt that he could not only produce achalasia by bilateral vagal section but that he could relieve it by sympathectomy Knight and Adamson³⁰ reported sympathectomy in five patients with, however only one resulting in complete relief and with three recurrences In one case reported by Schmidt¹⁵ bilateral cervicodorsal sympathetic ganglionectomy and trunk resection was performed with complete relief for fifty-two hours, after which sudden and complete closure of the esophagus appeared so that gastrostomy had to be performed Esophageal dilatations were used for eighteen months before the ability to swallow returned

The various types of medical therapy have been based upon attempts to stimulate or inhibit the activity of the sympathetic and parasympathetic systems Experimentally in human beings, with soft rubber balloons fixed in the cardia, morphine sulfate and amyl nitrite caused temporary relaxation Benzadrine sulfate produced relaxation for one hour followed by severe spasm for two hours Insulin in doses sufficient to produce symptoms of hypoglycemia brought about relaxation during the hypoglycemic period Adrenalin, sodium nitrate, mecholol and metrazol showed no definite relaxation Subcutaneous and intravenous atropine sulfate produced no consistent results Vinson¹⁷ stated that some of his patients have been improved with atropine, and others have received as much as 1.8 mg ($\frac{1}{25}$ gr) intravenously every hour until symptoms of poisoning developed with no evidence of relaxation of the cardia Douthwaite²² used amyl nitrite in the treatment of achalasia and found that although the period of relaxation was very short, frequent inhalations over a period of several months seemed to diminish the strength of the obstructive force

In the vast majority of cases, dilatation or mechanical stretching of the esophagus has proved successful We have seen how this was the procedure of Mikulicz Probably it was also the principle in the case reported by Willis although he interpreted it as a tamping process This simpler method of in

roducing a sound through the mouth has been used in more than 1,200 cases reported from the Mayo Clinic, and probably in 1,000 other unreported cases by various men throughout the country. A breakdown of cases in 805 patients treated in this manner showed 670, or 71 per cent, well, with one or more dilatations. In thirty-two there was no improvement. One hundred three considered themselves better but not well. Nine died in the hospital due to splitting of the esophagus, and two died of starvation. Twelve others died at home during the treatment, with the actual cause unknown.³³ The use of the Russell hydrostatic dilator is advocated by Plummer (quoted by Vinson¹⁷), Hoover,³⁴ and many others as a relatively safe procedure, since in most instances pain is produced by dilatation of the cardia. This enables the operator to judge the amount of pressure which may be used.

Pathology—The gross pathology is much more significant than the microscopic. Lambert³⁵ divided the gross findings into three types, fusiform, S-shaped or sigmoid, and flask (see Fig 1). These types probably represent variations in the degree of dilatation and lengthening of the esophagus subsequent to its obstruction. In determining optimal therapy, this degree of change must be considered. Rake³⁶ reported finding degeneration of nerve fibers in Auerbach's plexus. In some cases the wall becomes thicker but in others it appears normal. Hypertrophy and ulceration of the mucous membrane may occur.

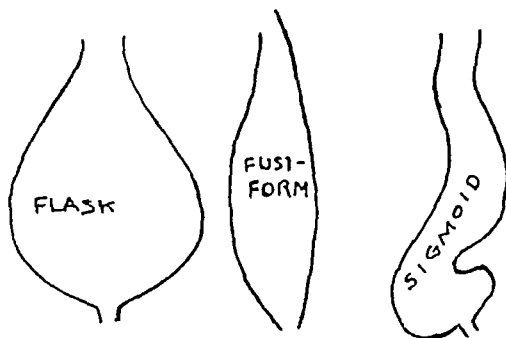


Fig 1—Three usual gross pathologic types of esophageal dilatation

The major complication without therapy has been pulmonary infection due to regurgitation of food. This sometimes occurs at night, without the patient's knowledge, simply as an overflow from a filled esophagus. Other complications are aggravation of already existing emotional instability, bleeding, and chronic cough. Death due to starvation has occurred. The complications following or during treatment by dilatation are the same as those previously mentioned, with the addition of rupturing the esophagus. Those following open operation are primarily infection with resultant peritonitis or mediastinitis and empyema, depending upon the use of the transabdominal or transthoracic approach.

Essential Indications for Therapy and Guides as to Choice of Therapy—One undoubtedly sees, in practice, many degrees of achalasia or cardiospasm. In fact, it can frequently be produced in an individual having no actual difficulties

by the giving of ice cold water when greatly overheated and exhausted by physical activity. Some have mild symptoms only in the morning or only when emotionally disturbed. Opposing these mild cases, one sees patients who (a) lose weight or, having lost weight remain in a more or less constant undernourished state, (b) those in whom dysphagia is marked and associated with sub-sternal pain and feelings of suffocation, and (c) those with actual vomiting. In these three types of cases it becomes necessary to institute some type of treatment more than simple advice concerning slow and thorough mastication, rest

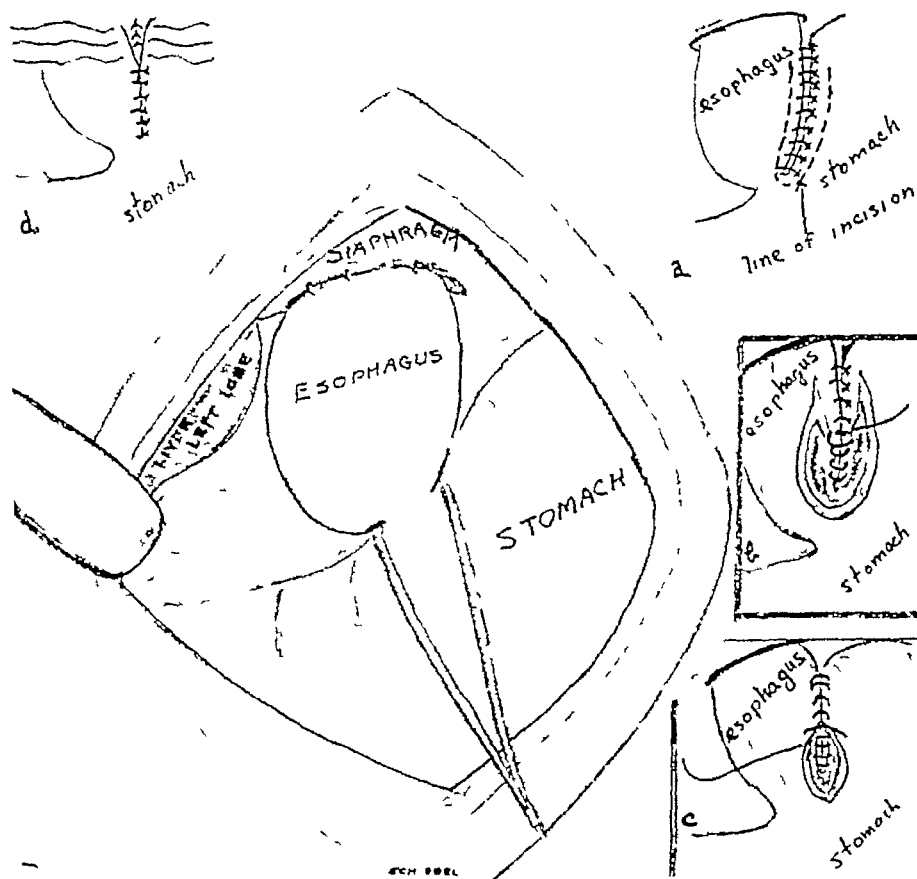


Fig 2—Esophagogastrostomy. Approach through a left rectus incision. The left lobe of the liver is retracted to the right after cutting the triangular ligament. The dilated esophagus has been pulled down through the opening in the diaphragm and is held by a linen tape or a soft rubber tube. In a, b, c, and d are shown the usual steps in performing a two-layer esophagogastrostomy.

before and after meals, use of warmed foods only, and antispasmodics. Dilatation by the passage of bougies and the use of the hydrostatic dilator becomes necessary, at first either with the aid of esophagoscopy or under fluoroscopic observation and later without such aid. In many instances, as the literature records, this is very effective. When, then, shall we institute a surgical approach such as cardioesophagoplasty? In my opinion, the following indications exist:

1 When roentgenographic examination discloses increased length of the esophagus with a sigmoid- or flask-shaped contour. In these dilatation is difficult, dangerous, and usually must be kept up more or less continuously.

2 When the patient, under proper care as to rest, types of food, and reasonably free from simple emotional exacerbation, necessitates dilatation frequently, such as once a week or several times each month. Under such circumstances the patient should be advised that an operative procedure is available which carries a high percentage of cures.

3 When the patient does not tolerate the procedure well because of fear and pain and has no possibility of learning the use of bougies without medical aid.

4 Finally, when the patient is geographically or financially unable to have frequent dilatations.

When such factors exist, operation is indicated and desirable. The technique has been adequately described by Ochsner and others (see Fig 2). The transperitoneal approach is preferred and the operation is not a difficult one. Both spinal and inhalation anesthesia have been used with identical results. The following case histories illustrate common symptoms, findings, and results to be expected.

CASE REPORTS

CASE 1—J. R., a 56 year old colored man, tenant farmer was admitted to Lincoln Hospital on Jan. 19 1943 complaining of inability to swallow food or water for three days. His general health had always been good until five or six years before admission. Since then he had had occasional attacks of nausea coming on immediately after eating and lasting one or two days. Ten months before, and continuing until admission, he began to have frequent bouts of vomiting after eating, with regurgitation of food, both solid and liquid. Attacks of this were very severe for two to three days, and then much improvement took place for a few days. For three days prior to admission he had not even been able to swallow water. He lost eighty pounds in the preceding nine months. Previous roentgenograms had been made but were not available. Several dilatations had been attempted unsuccessfully.

On examination, nothing unusual could be found except obvious dehydration and weight loss. The skin was loose and inelastic. Height was 76 inches, weight 170 pounds. Roentgenograms showed elongation and dilatation of the lower portion of the esophagus and complete obstruction with a smoothly rounded lower end (see Fig 3). A diagnosis of cardiospasm was made and operation advised. Adequate fluids and vitamins were administered and the esophagus lavaged twice daily.

On January 25, operation was performed under spinal anesthesia, 20 mg of pontocaine. Prior to beginning this, the phrenic nerve was visualized on the left side of the neck under local anesthesia and was crushed. An upper left rectus incision was made. The abdominal contents appeared normal. The suspensory ligament of the left lobe of the liver was divided and the lobe retracted toward the right side. The cardioesophageal junction was visualized. The peritoneum covering this was incised. The vagus nerves were identified and avoided. The esophageal hiatus was dilated and the esophagus gently mobilized until 12 cm was brought below the diaphragm. It was dilated to about 5 to 6 cm, and the wall was quite thickened. The musculature at the cardioesophageal junction appeared normal, but the opening seemed very small. The esophagus was sutured to the diaphragm at the new level. A posterior row of interrupted No. 40 cotton sutures was placed joining the stomach and the esophagus. A U shaped incision was then made through all the layers of the esophagus and the stomach, each limb being about 4 to 5 cm long. A continuous No. 00 chromic catgut suture united these raw edges. A final anterior row of cotton sutures was placed. After this the redundant

portion of the stomach was loosely attached to the lower portion of the esophagus. The left lobe of the liver was replaced. Five grams of sulfanilamide powder were sprinkled into this area and a single cigarette drain placed just to the right of the esophagus. The wound was closed with No. 00 chromic catgut for the peritoneum, interrupted No. 40 cotton for the fascia, and No. 60 for the skin.

The wound healed per primam. Sterile water was given in small amounts after forty-eight hours and full liquids after ninety-six hours. Solid food was started on the ninth day, and the patient was discharged home on the thirteenth postoperative day. Prior to discharge fluoroscopy was done on the patient after a barium swallow, and it was seen to pass readily and easily into the stomach. There was still an increase in the diameter of the esophagus.

One month later, he had gained twenty pounds in weight, and on Nov. 5, 1944, his family physician reported that he was well, working daily, and weighed 240 pounds.



Fig. 3 (Case 1) —Preoperative x-ray view of the esophagus. Filling is poor due to presence of old food mixed with barium. The esophagus is outlined with a black line.

CASE 2—C. B., a 23-year-old millworker, was referred by a bronchoscopist on Feb. 12, 1943, with a diagnosis of cardiospasm, for consideration of surgical therapy. At the age of 12, eleven years before admission, he noticed for the first time difficulty in swallowing food. He chewed food very slowly and thoroughly, but on attempting to swallow he found it difficult and had a sensation of something stopping in the lower portion of the chest directly beneath the sternum. He stood up, walked around trying to swallow, and drank water, hot tea, or coffee to try more forcefully to get food to pass through. At times even a glass of water could not be swallowed until he stood up and walked. Anything cold was much worse than warm food or drink. It had been impossible to eat ice cream for eleven years. The usual cold lunch was the most difficult, and finally the patient gave up even carrying lunch to work, depending upon a slowly eaten warm breakfast and supper. In October, 1942, the patient first sought medical aid, and from then until Feb. 12, 1943, he had dilatations every three to six weeks. Relief was not marked and never lasted more than two weeks and usually only about seven days.

The patient refused all invitations to dine out because of the difficulty in swallowing. For two days prior to examination he had been unable to drink much water. Vomiting of small amounts of undigested food eaten recently or sometimes twelve to twenty-four hours before occurred occasionally.

Past history was negative except for a history of poliomyelitis in childhood. He was very active in sports, playing semiprofessional baseball and basketball. He tried to eat all types of food except cold things and used no alcohol or tobacco.

On examination the patient was a well developed, thin, quiet, and cooperative young white man. There was slight atrophy of the musculature of the right lower leg but no paralysis nor demonstrable weakness. Weight was 126 pounds, height 70½ inches. Roentgenographic examination of the upper gastrointestinal tract showed marked cardiospasm, with the lower portion of the esophagus two inches in diameter. Barium passed into the stomach in extremely small amounts very slowly.

The patient found the frequent dilatations uncomfortable, distasteful, time consuming, and expensive. A cardioplasty was advised, but the patient delayed admission to the hospital until June 2, 1943. On admission, the findings were the same as before except for a continued weight loss down to 116 pounds. Esophageal lavage brought up between 500 and 700 cc of food particles and liquid, morning and evening, for several days. On the morning of operation 250 cc of watery fluid were aspirated, after having nothing by mouth for seven hours and water only for six hours prior to that.



Fig 4 (Case 2)—Roentgenogram taken eighteen months after esophagogastrostomy. The esophagus was narrow and emptied readily.

On July 4, an esophagogastrostomy was performed through a left upper rectus incision under avertin and nitrous oxide ether anesthesia. The thoracic cage was long and the costal flare very narrow, so that exposure was unusually difficult. The abdominal contents were normal. After cutting the suspensory ligament of the left lobe of the liver, the esophageal hiatus was found, the esophagus mobilized and pulled downward about 8 to 9 cm. A two layer anastomosis was made in the manner shown in Fig 2. Interrupted cotton sutures were used for the outer row of sutures and continuous No 00 chromic catgut for the inner approximating suture. Five grams of sulfanilamide crystals were sprinkled loosely in and around the anastomotic area. The diaphragm was resutured to the esophagus about 1½ cm above the anastomosis which had an opening 5 cm in diameter. The liver was replaced in its normal position. The abdomen was closed with a continuous No 00 chromic catgut for the peritoneum, interrupted No 40 cotton sutures for the fascia, and interrupted No 60 cotton sutures for the skin. A single cigarette drain was brought out of the upper angle of the wound.

The immediate postoperative course was uneventful except for a mild febrile reaction for three days. Sterile water was started by mouth after forty eight hours, and clear liquids on the fourth day. A soft diet was given on the seventh day. Two days later the wound became puffy and red and was rather tender. There was no temperature elevation. The wound was opened slightly and 40 cc of yellowish gray purulent material were evacuated. Culture of this showed *Staphylococcus albus* and mixed organisms. The wound healed slowly but completely, and he was discharged home on the twentieth postoperative day.

He gained weight slowly and returned to all usual activity in eight weeks. Several weeks later he was able to eat ice cream again. Roentgenograms on Dec 1, 1944, showed a

large opening into the stomach with no delay in the passage of barium (see Fig 4) On Nov 1, 1945, his weight was 156 pounds, and he considered himself perfectly well

CASE 3—R K, a 26 year old white man, a clerk, was referred on Aug 30, 1944, with a diagnosis of cardiospasm His parents stated that, at the age of 10, he began to lose weight and from that time on was always thin and lacking in strength and energy Intermittently he would regurgitate food immediately after eating At times he felt too weak to continue work Fluids were just as difficult to swallow as solid food during the last six months Numerous attempts were made to dilate the cardia at several hospitals during the previous two years, and the patient was sent home to continue dilatations at home with a hydrostatic dilator Many times it was impossible, and always it was very difficult to pass the dilator, at best relief was obtained for only seven to ten days The past history was otherwise negative except for repair of an indirect inguinal hernia four years previously Convalescence was uneventful



Fig 5 (Case 3)—A, Preoperative study of esophagus note flask shape This esophagus measured 14 cm in width B View of esophagus two weeks after esophagogastrostomy There is still some dilatation but barium passed into the stomach easily

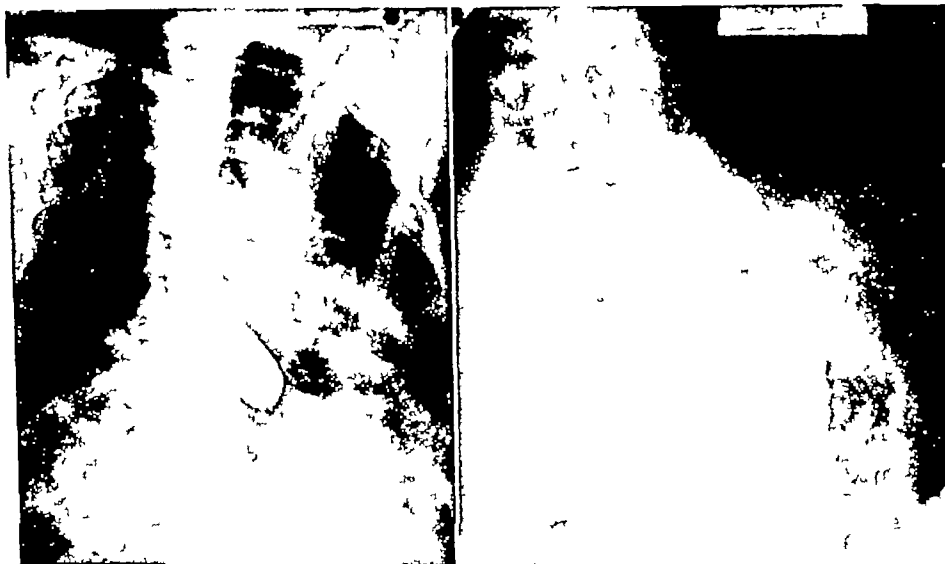
On physical examination, the patient was tall, thin, appeared dehydrated, and chronically ill Height was 71 inches and weight 120 pounds The blood pressure was 125 systolic and 80 diastolic Routine blood and urine studies were negative There was a well healed left inguinal scar All other findings were negative except for considerable widening of the retrosternal dullness Previous reported roentgen ray studies showed a huge dilated sigmoid type esophagus which curved far out to the right side (see Fig 5, a) There was no passage of barium into the stomach for about three hours Slowly from then on, the barium passed through The greatest diameter of the esophagus was 14 cm. as measured roentgenographically A stomach tube was inserted six hours later, and 1½ pints of barium, old food, and mucous material was aspirated A diagnosis of achalasia was made

The esophagus was lavaged twice daily for several days

On Sept 2, 1944, an esophagogastrostomy was performed under continuous spinal anesthesia, supplemented by celiac plexus infiltration of 40 cc of 1 per cent novocain The exposure and the procedure were the same as outlined in the other cases The lower end of the esophagus was very narrow, measuring just 2 cm. in diameter, and the wall was very thick A two layer anastomosis was made, using interrupted cotton for the outer layer and

No 000 chromic catgut for the inner layer. A single cigarette drain was brought out through a stab wound to the left of the incision, and closure was the same as used in the other cases.

The convalescence was uneventful. The drain was removed in four days, and the patient was ambulatory after the seventh day. He was started on water after two days and progressed to a normal diet on the tenth day, at which time he was discharged. Ten weeks later he returned for postoperative examination. The weight was 153 pounds, a gain of thirty-three pounds. The patient felt well, and his wife added that he had several times mentioned that he felt happy and contented since his operation, and that she had never heard him say this in their previous years of married life. Postoperative roentgenographs showed barium passing readily into the stomach, although all dilatation had not yet disappeared (see Fig 5, b). In October, 1945, he reported that he was still feeling well and eating all foods normally.



A

B

Fig 6 (Case 4)—A. A sigmoid or hockey-stick type esophagus with marked delay in the emptying time. This view was taken twenty minutes after swallowing the barium meal. B, X-ray picture made two weeks after esophagogastrostomy. There is some deformity of the cardiac end of the stomach apparently due to inflammatory reaction in the left subdiaphragmatic area but the esophagus empties readily.

CASE 4—J. D., aged thirty-six years, a colored man, a truck driver, was first seen in consultation on Nov. 28, 1944, with a complaint of dysphagia of six to eight years' duration. Until two years before this occurred only in attacks or waves lasting three to seven days and often with a free interval of four to eight weeks. For the previous two years the dysphagia had been present all the time, although the degree fluctuated constantly. During this time, he would actually vomit most of the ingested food or liquid for a few days and then perhaps improve again. He had been unable to eat or drink anything cold for two years. He was unable to relate the attacks to any type of food, or to any factor in his work or home life. Roentgenograms previously made showed achalasia of the cardia and considerable dilatation and elongation of the esophagus. He was advised to have esophagoscopy and dilatations and returned to his home for this. On May 14, 1945, he returned worse than before, despite dilatations with a hydrostatic bougie approximately every fourteen days. He had lost fourteen pounds in weight and was regurgitating food from the noon and evening meals almost daily.

General examination was not remarkable. Blood and urine studies were negative. He seemed very phlegmatic throughout all the studies. X-ray examination showed a sigmoid type esophagus with considerable dilatation, and only a small trickle of barium passed through

the cardioesophageal junction, despite vigorous contraction waves. The barium stream passing through was about 3 mm in diameter, and at the end of twenty minutes the esophagus was still very full (see Fig 6, a).

On May 21, 1945, an esophagogastrostomy was performed, transabdominally, under spinal anesthesia. The exposure was difficult, and the stomach, despite frequent lavages, seemed rather full. There was some soiling of the operative field with this when the cardia was opened. Otherwise the usual procedure was carried out, and a drain was inserted through a stab wound on the left side. This was removed on the fourth day, after which the patient developed considerable fever and, on the tenth day, began to drain thick, foul purulent material from this stab wound, although the original incision, closed throughout with interrupted cotton, remained well healed. The fever subsided, but the drainage persisted intermittently for two months, during which time the postoperative x-rays were taken (see Fig 6, b). These showed considerable spasm around the cardiac end of the stomach, but the anastomosis was functioning well. Therefore, on July 20, 1945, the left subdiaphragmatic region was explored posteriorly and, although no actual abscess could be found, drains were inserted, and within ten days all anterior drainage had ceased, and he was much improved. The posterior drains were removed, and the wound healed slowly. He was discharged on the twentieth postoperative day, remaining well since that time.

SUMMARY

All patients with dysphagia and regurgitation should be carefully studied. Those which are due to idiopathic spasm of the cardioesophageal junction must be differentiated as to degree and type of secondary deformity of the esophagus. Drugs, careful slow eating, avoidance of emotional stress, and dilatations should be used. For patients with large, flask-shaped or sigmoid type of dilatation and for those who do not respond well to conservative therapy, esophagogastrostomy is indicated. A report of four cases selected according to these criteria is presented. They have been followed from six to thirty-five months and the patients appear well clinically and roentgenographically.

REFERENCES

- 1 Major, R. H. *Classic Descriptions of Diseases*, Springfield, 1932, Charles C Thomas, p 591.
- 2 Osgood, Hamilton. *A Peculiar Form of Oesophagismus*, Boston M & S J 120 401 405, 1889.
- 3 Guisez, J. *A propos des sténoses congénitales de l'oesophage*, Clinique, Paris 34 163 165, 1939.
- 4 Walton, A. J. *The Surgical Treatment of Cardiospasm*, Brit J Surg 12 701 737, 1925.
- 5 Von Mikulicz, J. *Zur Pathologie und Therapie des Cardiospasmus*, Deutsche med Wchnschr 30 17, 1904.
- 6 Gray, Howard K., and Skinner, Ira C. *The Operative Treatment of Cardiospasm*, J Thoracic Surg 10 220 235, 1940.
- 7 Alvarez, W. C. *The Mechanics of the Digestive Tract*, Ed 2, New York, 1928, Paul B Hoeber, Inc., pp 82 93.
- 8 Comby, J. *Pharyngisme et esophagisme chez les enfants*, Arch de méd d enf 23 247 250, 1920.
- 9 Jacobson, Edmund. *Spastic Esophagus and Mucous Colitis. Etiology and Treatment by Progressive Relaxation*, Arch Int Med 39 433 445, 1927.
- 10 Muggia, Alberto. *Spasmo dell'esofago e Tetania nel Lattante*, Lattante 1 524 526 1930.
- 11 Bruhl, H. *Der kindliche Oesophagospasmus*, Ztschr f Laryng Rhin, Otol 21 1 1931.
- 12 Sudhues, Maria. *Über den Speiseröhrenkrampf beim Kinde*, Arch f Kinderh 96 65 88, 1932.
- 13 Weiss, Edward. *Cardiospasm. A Psychosomatic Disorder*, Psychosom Med 6 58 70, 1944.

- 14 Ochsner, Alton, and DeBakey, Michael The Surgical Treatment of Achalasia of the Oesophagus, Surg, Gynec & Obst 72 290 295, 1941
- 15 Schmidt, Herbert W Diffuse Spasm of the Lower Half of the Esophagus, Am J Digest Dis 6 693 700, 1939
- 16 Heyrovsky, H Casuistik und Therapie der idiopathischen Dilatation der Speiseröhre, Oesophago Gastroanastomose, Arch f klin Chir 100 703, 1913
- 17 Vinson, Porter C Cardiospasm, Am J Surg 56 79 85, 1942
- 18 Jaffie, K Ueber idiopathische Oesophaguserweiterung, Munchen med Wehnschr 44 386, 1897
- 19 Freeman, L An Operation for Relief of Cardiospasm Associated With Dilatation and Tortuosity of the Esophagus, Ann Surg 78 173 175, 1923
- 20 Heller, E Extramuköse Cardioplastik beim chronischen Cardiospasmus mit Dilatation des Oesophagus, Mitt a d Grenzgeb d Med u Chir 27 141, 1914.
- 21 Womack, N A Esophagoplasty for Esophageal Achalasia S Clin North America 18 1241 1254, 1938
- 22 Finney, J M T A New Method of Pyloroplasty, Bull Johns Hopkins Hosp 13 155, 1902
- 23 Haggstrom, P, quoted by Sturtevant, M Cardiospasm, With a Review of the Literature, Arch Int Med 51 714 736, 1933
- 24 Kredel, Frederick E Surgical Treatment of Cardiospasm, South Med & Surg 104 258 259 1942
- 25 Sprunt, W H, and Harrill, J A Cardiospasm North Carolina M J 5 238 241, 1944
- 26 Wachs, E Ueber Methoden der Kardiospasmusbehandlung und ihre Erfolge, Arch f klin Chir 200 259 266, 1940
- 27 Grimson, K. S., Taylor, H M, Trent, J C, Wilson, D A, and Hill, H C The Effect of Transthoracic Vagotomy Upon the Functions of the Stomach and Upon the Early Clinical Course of Patients With Peptic Ulcer, South M J 39 460-470, 1946
- 28 Grondahl, J W, and Haney, H F An Attempt to Produce Experimental Cardiospasm in Dogs, Proc Soc Exper Biol & Med 44 126 129, 1940
- 29 Knight, G C The Relation of the Extrinsic Nerves to the Functional Activity of the Esophagus, Brit J Surg 22 155 168, 1934
- 30 Knight, G C, and Adamson, W A D Achalasia of Cardia, Proc Roy Soc Med 28 891 897, 1935
- 31 Knight, G C Sympathectomy in the Treatment of Achalasia of the Cardia, Brit J Surg 22 864 876, 1935
- 32 Douthwaite, A H Achalasia of Cardia, Treatment With Nitrites, Lancet 2 353 354, 1943
- 33 Moersch, Herman J Cardiospasm, Its Diagnosis and Treatment, Ann Surg 98 232 238, 1933
- 34 Hoover, Walter B Cardiospasm An Analysis of Twenty five Consecutive Cases, S Clin North America 23 827 829, 1943
- 35 Lambert, A U S Treatment of Diffuse Dilatation of the Esophagus by Operation, Surg, Gynec & Obst 18 1, 1914
- 36 Rake, G W On the Pathology of Achalasia of the Cardia, Guy's Hosp Rep 77 141 150, 1927

SURGICAL REMOVAL OF LARGE RETROPERITONEAL LUMBAR GANGLIONEUROMA

A CASE REPORT

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ATTENTION was first called to the unusual tumor described in this article by the case report of Loietz¹ in 1870. Although it was a mediastinal ganglioneuroma found at autopsy, it was the first time that this tumor was described as a separate entity. Prior to that time all such tumors were classified with the neuromas. For the next eighteen years not a single tumor of this type was reported. It was not until 1898 that the next report of a ganglioneuroma appeared in the literature. This was a report of a retroperitoneal pelvic ganglioneuroma by Busse². Since then, however, the stream of case reports describing this unusual type of tumor has been steady, until at the present time about 200 cases of authenticated ganglioneuroma throughout the body have been reported. McFarland,³ in 1931, reported a case and surveyed the literature very carefully. He tabulated all the cases reported to date as to location in the body. A glance at his survey of the literature readily discloses the fact that a ganglioneuroma can and often does arise in almost any part of the body. The only necessary antecedent to the development of this tumor is the presence of misplaced neurocytes. As a result we find ganglioneuromas in the central nervous system, in the cranial nerves, roots or ganglia, in the neck, in the thorax, in the gastrointestinal tract, in the adrenal, in the pelvis, retroperitoneal, and peripherally, as even in the knee. The lumbar type of retroperitoneal ganglioneuroma appears to be one of the uncommon sites of origin of this tumor. In McFarland's survey of the literature, he listed thirty-two reports of retroperitoneal ganglioneuromas. Because of World War II, it has been impossible at this time to obtain copies of case reports from the Japanese, Russian, Czechoslovakian, and Italian literature which are listed in the *Quarterly Cumulative Index Medicus* as reporting one to two cases in each language. For this reason, if we accept the cases reported in these languages, the total number of retroperitoneal lumbar cases reported is somewhat less than fifty. Many of these patients were operated upon, although some of the tumors in this location were found incidental to autopsy. Among those operated upon, many of the patients died and in many the tumor could not be completely removed due to its fixity to the aorta, iliac arteries, or ureter. All surgeons stress the great difficulty in removing these tumors not only because of their proximity to great vessels, but also because of the great vascularity in the tumor itself. The collapse (circulatory) of the patient either during or after the operation was a very common accompaniment of this type of surgery. In Kehrer's⁴ report, the iliac artery was torn and the patient died,

in von Salacz's report⁵ the common iliac artery required suture and the patient died, King⁶ and also Evans and Francona⁷ in their case reports stressed the fact that the patients operated upon so often went into shock

The consensus of opinion at the present time is that these tumors are congenital in origin. They are thought to arise from cells that were displaced or miscarried during the migration of the ganglionic crests during embryonic life. In man and higher mammals, the sympathetic ganglion organization⁸ is the result of a migration of individual cells from the neural crest substance down the dorsal nerve roots and peripheral trunks to form paired ganglionic clusters dorsolateral to the aorta. As early as 5 mm embryo (five weeks), these sympathetic primordia can be found throughout most of the extent of the trunk dorsolateral to the aorta. These cells may never reach the ganglionic mass and may become arrested or displaced anywhere along the way. Such cell rests may remain quiescent forever and never give rise to any difficulty, or they may begin to proliferate at any period of antenatal or postnatal life. The type of tumor that is formed by these cells depends upon the level of differentiation that has been attained before neoplastic development took place. Since these primordial cells become differentiated to neurocytes which then develop into neuroblasts or pheochromoblasts, and ultimately develop into ganglion cells and pheochromocytes, it becomes quite evident that theoretically five different types of tumor would be possible. Actually, however, only three types of tumors arise from the neurocytes. These are neuroblastoma, pheochromocytoma, and ganglioneuroma. Pheochromoblastoma and neurocytoma have not been described in the literature as yet. Of the three tumors that have been described in the literature, the ganglioneuroma represents the neoplastic development of the mature cell, or rather the neoplastic development after the neurocyte has reached the end stage of its development. Of these three types of tumor, only the ganglioneuroma lacks clinical characteristics permitting the clinician to make a diagnosis. The rapidly growing tumors, usually found in the renal area of children under 4 years of age, are highly suggestive of a neuroblastoma to the clinician, and the presence of a tumor mass in the renal area associated with paroxysmal hypertension⁹ is almost pathognomonic of a pheochromocytoma. From the clinician's point of view, the only characteristic feature of the ganglioneuroma is the presence of a large tumor mass with a complete absence of characteristic clinical features. The tumor may be present for many years without producing any symptoms. In the case report of von Salacz, the tumor had been present for fourteen years that the patient was aware of without producing any clinical symptoms whatever. It is this one feature that we believe could help the clinician to arrive at a presumptive diagnosis of ganglioneuroma. That is, the presence of a soft or moderately firm tumor of oval shape and large size, situated to one side of the midline, fixed posteriorly, and present for years without producing symptoms.

Although textbooks¹⁰ and most articles call this tumor a pathologically benign one, nevertheless, there have been case reports indicating that it may

become malignant.¹¹ Malignant degeneration of the ganglioneuroma must be exceedingly rare, however, judging from these few isolated case reports.

Although the tumors are usually single, there have been two case reports of multiple ganglioneuromas.



Fig 1—Note that the left kidney has been distorted by the presence of the ganglioneuroma. Note the depression of the calyces at the upper pole.

The case we are reporting includes all the characteristic features of a ganglioneuroma, namely, the presence of an asymptomatic tumor of large size in the left renal area, displacement of the left kidney with distortion of the pyelogram (see Fig 1) without invading the kidney, extreme vascularity of the tumor, and its difficulty in removal.

CASE REPORTS

G T, a 55 year old white woman, was admitted to the Grace Hospital complaining of "gas pains" and a mass in the left side. The patient had been complaining of "gas pains" over the abdomen on the left side for some years. The pain radiated to the back on the left side. She had nausea at times but never vomited. She had been constipated for many years. Past history was entirely negative. Upon examination, the patient was found to be a middle aged white woman, she lay easily in bed and did not appear acutely ill. Temperature was 99° F, pulse 72, and respirations 20. Examination of head and neck showed no abnormality. Heart was normal in size and position. There were no murmurs, rate and rhythm were normal. There were no dropped beats. Blood pressure was 140/80. Lungs were resonant to percussion. Tactile fremitus was normal. There was bronchovesicular breathing. No râles. Abdomen revealed no distention or rigidity. There was no fluid wave or shifting dullness. A large, firm, nontender mass was easily palpable in the left hypochondrium. It did not move with respiration and appeared fixed deeply. Extremities were normal, reflexes, negative.

Laboratory examination revealed blood type 4, hemoglobin 10.2 Gm (63 per cent), red blood count, 3,230,000, white blood count, 13,200, polymorphonuclears, 87 per cent, filament, 75 per cent, nonfilament, 12 per cent, lymphocytes, 12 per cent, monocytes, 1 per cent. Urine was amber, clear, and alkaline. Specific gravity was 1.019, albumin, negative, sugar, negative, sediment, occasional epithelial cell. Reticulocytes were 0.4 per cent. Coagulation time was 3¼ minutes, prothrombin time, 65 per cent, bleeding time, 1 minute. Skin test for undulant fever gave negative results, as did the agglutination test for typhoid, paratyphoid, and Malta fever. Blood cholesterol was 115 mg, nonprotein nitrogen, 25.5 mg, whole blood chlorides, 528 mg. Examination of urine obtained from kidney pelvises revealed, left kidney white blood cells, few, red blood cells few, cast, negative, smear, negative, culture, staphylococcus, acid fast, negative. Right kidney white blood cells, few, red blood cells, none, casts, negative, smear, negative, culture, staphylococcus, acid fast, negative. Stool examination showed hard stool, medium brown, occasional red and white blood cells.

On May 11, 1945, cystoscopy was carried out on the patient. It was found that, using a nupercaine 1:500 anesthetic, a No. 21 cystoscope passed easily into the bladder. The bladder mucosa was within range of normal and the bladder capacity was normal. No stone, diverticula, or trabeculations were seen. Both ureteral orifices were normally placed. The right was normal in appearance and function, the left slightly reddened in appearance. No. 5 catheters passed 25 cm into either ureteral orifice without obstruction. Divided urines collected and intravenous indigo carmine appeared on the right in good concentration in five minutes and on the left in fourteen minutes. However, the concentration was good on the left after appearance and it is questionable whether the delay in appearance was due to obstruction at the catheter tip. Bilateral pyelograms were made with the patient in the flat and upright positions as well as in the lateral position.

By roentgen examination (retrograde pyelogram) both kidneys appeared to be normal in size and shape, both of them were somewhat ptosed. The one on the left appeared to be depressed at its superior pole by a large soft tissue mass noticed in the left upper quadrant. This was in all likelihood a large spleen. Calcified mesenteric glands were noted in the region of the right sacral wing. Psoas muscles were clearly visualized and appeared to be normal. No evidence of a urinary tract stone was noted. Catheters had been introduced into the kidney pelvis on the right and ureteropelvic junction on the left. Opaque dye was injected by the instrumental method and a normal outline of the right urinary tract was obtained while upper calyx and infundibula appear to be somewhat depressed, on the left, by outside pressure from the previously described soft tissue mass—thought to be an enlarged spleen. The conclusion was essentially normal bilateral instrumental pyeloureterography with depression of upper left renal lumina by an enlarged spleen.

Barium enema, on initial fluoroscopic review of the chest and abdomen, detected no evidence of grossly pathologic conditions in these areas. The barium enema was given under fluoroscopic control, without undue difficulty, and filled a rather redundant colon which

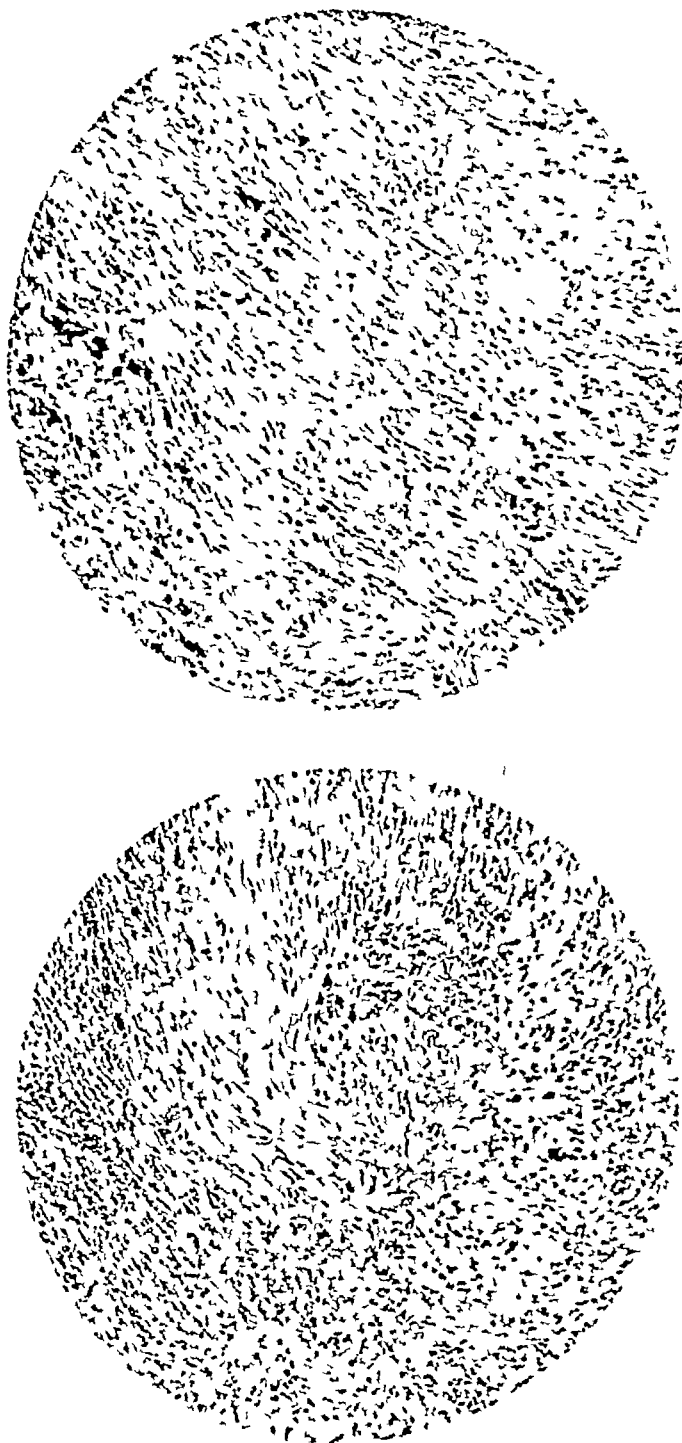


Fig 2—Note the nerve fibers throughout the section

otherwise appeared to be normal. Roentgenograms were obtained before and after partial expulsion of the contrast clysm. These readily confirmed the fluoroscopic impressions. The conclusion was markedly redundant colon.

Cholecystogram revealed a normal gall bladder with no evidence of calculi. A somewhat irregularly shaped mixed opaque and radiopaque, somewhat oval shadow was noted to be lying just lateral to the right transverse process of the fifth lumbar vertebra, superimposing the wing of the ilium and probably representing a calcified mesenteric gland although the possibility of it being due to undissolved gall bladder dye cannot be ruled out from this examination alone.

On May 15, 1945, a sternal bone marrow puncture was performed. Examination of this marrow revealed promyelocytes 3 per cent, neutrophile myelocytes 14 per cent, neutrophile metamyelocytes 12 per cent, neutrophile stab forms 27 per cent, filamented forms 27 per cent, eosinophiles 1 per cent, eosinophilic myelocytes 1 per cent, lymphocytes 2 per cent, orthochromic normoblasts 6 per cent. The impression was hypoplastic for myeloid and erythroid elements.

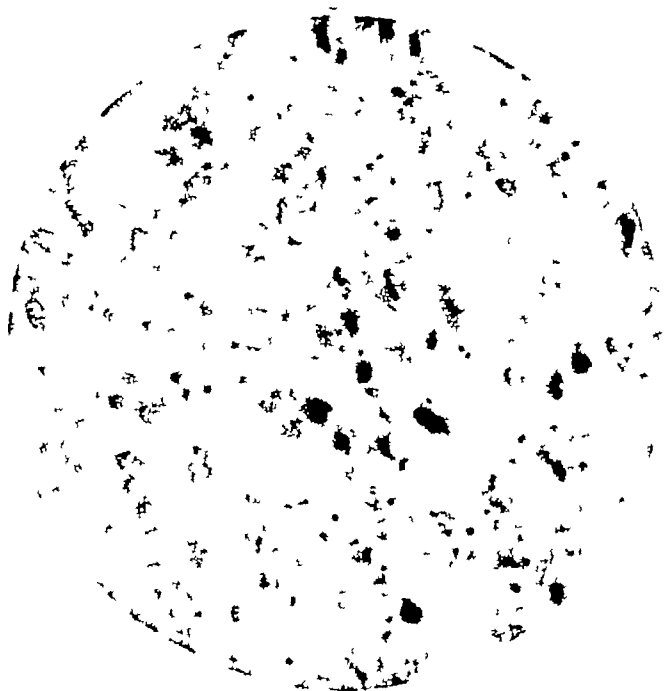


Fig. 3—Note the atypical ganglion cells; the entire tumor consisted of myelinated and nonmyelinated nerve fibers and these atypical ganglion cells.

The patient was taken to the operating room on May 23, 1945. Under continuous spinal anesthesia, a transverse incision was made on the left side, one inch above the umbilicus, cutting across the rectus sheath and muscles. The abdomen was opened. A large mass was present in the left upper quadrant of the abdomen lying retroperitoneally with the descending colon and splenic flexure fastened above it. It was readily seen to be impossible to remove the mass through this incision, therefore a vertical incision was made along the edge of the rectus muscle from this incision. This gave wide exposure to the entire left side of the abdomen. The tumor was felt to be above the left kidney. It had pushed down below the umbilicus. An incision was now made twelve inches in length on the outer peritoneal surface. The descending colon and transverse colon were then separated from the tumor and pushed toward the midline. The tumor was then shelled out from its bed situated just above the left kidney and intimately attached to the bare area on the spleen just below the splenic ligament.

When separating the tumor mass from the spleen, the splenic artery was damaged and severe hemorrhage occurred. This necessitated clamping the splenic artery and vein and removing the spleen. The splenic artery and vein were ligated with a silk ligature. The tumor was then readily removed. There was added amount of oozing from the retroperitoneal space which was readily controlled with three abdominal packs. These were removed and the retroperitoneal space closed by sewing together the incision in the peritoneum. Two Penrose drains were left in the cavity and brought out through the incision. The wound was then closed in layers. For closure, continuous chromic was used to the peritoneum, interrupted No. 32 stainless steel wire to the fascia, skin clips for the skin.

The patient was given four transfusions of 500 cc of whole blood each, during the postoperative period. Convalescence was smooth, and the patient was discharged as cured on the eleventh postoperative day.

Pathologic report revealed that grossly the specimen consisted of a large tumor mass measuring 18 by 15 by 12 cm. The serosal surface of the mass was bluish gray in color. It was rough and covered with numerous fine adhesions. The mass was lobulated and well encapsulated. The capsule measured 2 mm in thickness. On section, the tumor was found to be made up of tissue which varied markedly in color and consistency in different areas. In some areas, it was cartilaginous and pinkish red. In others, it had an orange color and in still other areas it was yellow and soft and edematous in consistency. Microscopic examination showed the tumor mass to be made up of nerve tissue of three different types. One type of nerve tissue found was the myelinated nerve fibers. The other type found was unmyelinated nerve fibers (see Fig. 2). In addition to the myelinated and unmyelinated nerve fibers, there were a number of atypical ganglion cells (see Fig. 3). The new growth did not appear to be malignant. Diagnosis was ganglioneuroma.

SUMMARY

The case report exemplifies the cardinal features of this uncommon interesting tumor. In the past, none of these tumors were diagnosed either preoperatively or during the life of the patient. With the clinical data that have been accumulating, however, we believe that a presumptive diagnosis, at least, could be made in these cases. The great value of such a diagnosis lies in the fact that the treatment is entirely surgical. Since malignant degeneration is very rare, it is only necessary to remove the tumor completely to cure the patient effectively. Here again, the surgeon must realize that one of the characteristic features of the tumor is its fixity to circumjacent structures, particularly large vessels, and the marked vascularity of the tumor itself. All patients must be adequately prepared preoperatively with whole blood transfusions, and must be given blood both during and after the operative removal. Furthermore, the great tendency of these patients to go into shock during and shortly after the operation must be taken into consideration and measures to counteract this taken immediately. In those cases in which the tumor can be completely removed, the patient is cured.

CONCLUSIONS

- 1 The characteristic feature (clinically) of a ganglioneuroma is the presence of a large tumor for many years without any clinical symptoms whatever.
- 2 The tumors are very difficult to remove because of their vascularity and adherence to circumjacent structures.

3 Patients who have retroperitoneal tumors, of this type, removed show a great tendency to go into shock during or shortly after operation

4 If the tumor is completely removed, the patients are cured since malignant degeneration is rare

REFERENCES

- 1 Loretz, W Ein Fall von gangliosem Neurom, Arch f path Anat [etc], Berl 49 435 440, 1870
- 2 Busse, A Ein grosses Neuroma Gangliocellare des Nervus sympathicus, Virchow's Arch f path Anat [etc], Berl (Supplement) 151 66, 1898
- 3 McFarland, J Ganglioneuroma of Retroperitoneal Origin, Arch Path 11 118 124, 1931
- 4 Kehrer, E, reported by Clayton, S G Case of Retroperitoneal Pelvic Ganglioneuroma, J Obst & Gynaec Brit Emp 51 44 48, 1944
- 5 von Salacz, P Retroperitoneales Ganglioneurom, Ovarialgeschwulst vortauschend, Zentralbl f Gynak 60 1171 1178, 1936
- 6 King, E S J Ganglioneuroma of the Suprarenal Gland, Australian & New Zealand J Surg 13 123 128, 1943
- 7 Evans, J H, and Francona, N T Surgical Removal of Large Retroperitoneal Sacro lumbar ganglioneuroma, Am J Surg 48 675 680, 1940
- 8 Arey, L B Developmental Anatomy, Philadelphia, 1937, W B Saunders Company, pp 440-441
- 9 E C Baumgarten, and Cantor, M O Pheochromocytoma of the Adrenal, Ann Surg 3 112 116, 1940
- 10 Boyd, W Text Book of Pathology, Philadelphia, 1938 Lea and Febiger, p 326
- 11 Evans, J H, and Francona, N T Surgical Removal of Large Retroperitoneal Sacro lumbar Ganglioneuroma, Am J Surg 48 675 680, 1940

Review of Recent Meetings

REPORT OF THE 1946 MEETING OF THE SECTION ON SURGERY, GENERAL AND ABDOMINAL, OF THE AMERICAN MEDICAL ASSOCIATION

ROBERT R LINTON, M.D., BOSTON, MASS

THE Surgical Section of the American Medical Association convened in the auditorium of the War Memorial Opera House in San Francisco on the morning of Wednesday, July 3, 1946. The chairman, Daniel C Elkin, Atlanta, Ga, presided and Alton Ochsner, New Orleans, La, served as secretary.

Thomas B Aycock and James W Hendrick, Baltimore, Md. **The Problem of Phlebothrombosis and Thrombophlebitis**—The differentiation between phlebothrombosis and thrombophlebitis was stressed. It was pointed out that the symptoms of phlebothrombosis are often mild. The condition may occur in either medical or surgical patients. The source of pulmonary emboli as a rule is in the calf or plantar veins. Interruption of the femoral vein was recommended. The symptoms of thrombophlebitis are more pronounced but pulmonary emboli are less common. Paravertebral procaine injection of the lumbar ganglia, supplemented with bromsalzol, was recommended. It was reported that this treatment relieves the pain, reduces the temperature, and causes the edema to disappear with little or no permanent fibrosis.

Leo Loewe and Edward Hirsch, Brooklyn, N Y. **Heparin in the Treatment of Thromboembolic Disease**—The subcutaneous administration of heparin in the Pitkin menstrium was reported as a safe, simple, practical, and effective method for the treatment of thromboembolic disease, based on the results of observations in more than 200 cases. Four deaths were reported from fatal pulmonary embolism in this group. Experimental studies were carried out on the jugular veins in rabbits. These studies revealed, according to the authors, that heparin had a definite lytic effect on intravascular thrombosis produced by mechanical means. The authors believe that their experiment indicated that heparin increased the collateral venous return following interruption of the jugular vein in rabbits.

Arthur W Allen, Robert R Linton, and Gordon A. Donaldson, Boston, Mass. **Venous Thrombosis and Pulmonary Embolism. Comparative Study of Femoral Vein Interruption and Dicumarol Therapy**—Up to June 1, 1946, 1,300 patients were subjected to femoral vein interruption for the treatment of deep venous thrombosis and the prevention of pulmonary embolism at the Massachusetts General Hospital. No fatal complications resulted from the procedure. Six patients, who had had previous infarcts with diminished vital capacity, finally had sufficient additional emboli to cause death, but there was no case of sudden massive pulmonary embolus following bilateral femoral vein interruptions in these 1,300 patients. Prophylactic bilateral femoral vein interruptions were done in 357 patients. This procedure was recommended in patients over the age of 65 years subjected to major abdominal surgery for carcinoma. Controlled studies were carried out on a group of patients between the ages of 40 and 65 years, subjected to major surgical procedures, with small doses of dicumarol postoperatively to determine whether or not it would reduce the incidence of postoperative venous thrombosis. It was found that the incidence was reduced to 25 per cent of that seen in an untreated comparable group. Femoral vein interruption surprisingly produced little if any effect on the venous return from the legs. In none of the 1,300 patients was any serious sequelae noted, other than one chronic ulcer of the lower leg.

Geza de Takats, Chicago, Ill Sympathectomy for Peripheral Vascular Sclerosis—A group of fifty seven patients, suffering from vascular sclerosis of the lower extremities, was reported. Lumbar sympathectomy was performed if, after preliminary block of the lumbar sympathetics, the temperature of the digits rose, if walking ability improved, and if generalized vascular involvement was not too extensive. It was felt that the operation resulted in dramatic increase in walking ability in one group, amputation was averted in a second group, amputation could be performed at a lower level in a third group, and intractable neuritic pain of the causalgia type was improved in a fourth group. Good results were reported in fifty three cases, four were unsuccessful.

E Craig Heringman, James D Rives, and Harry A. Davis, New Orleans, La The Evaluation of Operative Procedure for Repair of Arteriovenous Fistulas Statistical Analysis of 53 Cases—Fifty three cases of arteriovenous fistulas were reviewed. The accepted methods of surgical treatment of arteriovenous fistulas were utilized in these cases. An analysis showed that transvenous restorative procedures were followed by significantly fewer cases of vascular insufficiency than when quadruple ligation or obliteration of the main artery was carried out. It was stressed that each patient should be carefully considered before deciding on which method should be used. Restoration of the continuity of the main artery was recommended as the operation of choice, since it was followed by the least evidence of vascular insufficiency.

E S Gurdjian and J E Webster, Detroit, Mich Newer Concepts in the Mechanism and Management of Head Injury—The mechanism of head injury was analyzed on the basis of recent work with electronic strain gauge measurement of deformations of the skull and study of changes in intracranial pressure detected by electrical means. Experimental animals were used to study the paths of strain following a blow of known quantity of energy. From a study of human fracture lines seen in roentgenograms, one may venture a guess concerning the area of impact at the time of accident. The management of head trauma was reported on the basis of lessons learned from researches into the chemistry of the brain following acute head injury.

Ralph Herz, Cleveland, Ohio Herniation of Subfascial Fat as a Cause of Low Back Pain Results of Surgical Treatment.—Severe pain in the back was reported to have been relieved in thirty seven patients by the surgical removal of a herniated mass of subfascial fat in the lumbar region. The diagnosis was confirmed by injection of procaine solution around the mass. Sudden strain apparently precipitates the herniation of fatty tissue, which then becomes edematous causing pressure, which may lead to severe back pain. Of the thirty seven cases reported, thirty four patients were completely relieved six months to three years following the operation.

Thursday, July 4 Election of Officers for 1947

Chairman's Address Daniel C Elkin, Atlanta, Ga Exposure of Blood Vessels.—A review of the exposure of the major blood vessels of the body was presented. The material for this presentation was obtained by the work carried out by the author at the Ashford General Hospital Vascular Center, White Sulphur Springs, Va., on soldiers from World War II suffering from injuries to major blood vessels secondary to missiles. An excellent description of the operative exposures for the major blood vessels of the upper extremity, neck, thorax, and lower extremity was given. The exposure of arteriovenous fistulas involving the posterior tibial and peroneal arteries, and utilizing the subperiosteal resection of the proximal portion and head of the fibula was of outstanding interest as a new approach to vascular lesions involving these vessels.

Francis D Moore, William P Chapman, Chester M. Jones, and Milford D Schulz, Boston, Mass Transdiaphragmatic Vagus Resection in Peptic Ulcer Physiologic Effects

and Early Results—The results obtained on forty selected cases of duodenal and jejunal ulcers treated during the past two years by transthoracic vagus resection were reported from the Massachusetts General Hospital. Many of the group had been subjected to surgical intervention prior to this procedure. Seven had jejunal ulcers and seven had bled in the past, two massively. In the short time since the operation on these patients, good symptomatic results with healing of the ulcers have been demonstrated. One patient failed to respond to the operation, in which the antrum of the stomach was still present following a sleeve resection of the mid portion of the stomach and a gastrojejunostomy. The physiologic observations carried out on these patients revealed a decreasing motility of the stomach with a diminished secretion but no change in the threshold of gastric sensation to the stimulus of balloon distention.

Richard B. Cattell, Boston, Mass. Benign Strictures of the Bile Ducts—An analysis of 123 benign strictures of the bile ducts was reported. Operative injury was responsible for 99. Repair of the common duct with end to end suture of the proximal and distal segments was stressed as the best method of repair, avoiding anastomosis to the gastrointestinal tract wherever possible. It was recommended that the anastomosis be done over a T tube, bringing the long arm out through a separate wound in the common duct distal or proximal to the end to end suture line.

Everett I. Evans, Richmond, Va. The Early Recognition and Management of Intestinal Strangulation—The differential diagnosis between simple and strangulation obstruction, based on the clinical signs and symptoms in seventeen patients with strangulation obstruction seen by the author, was reported. The clinical phenomena utilized in the diagnosis are the manner of onset of pain, a new sign, "position of relief," auscultation, and shock picture. The importance of early diagnosis and early surgical relief by operation was especially stressed, as it is only possible to reduce mortality in this manner.

Harry E. Bacon and Lowrain E. McCrea, Philadelphia, Pa. Abdominoperineal Proctosigmoidectomy for Rectal Cancer and the Management of Associated Vesical Dysfunction—The basis of this report was 430 patients with rectal and sigmoidal cancer. Operation was performed in 392, resection in 345. "Proctosigmoidectomy" was performed in 223 instances with division but preservation of the sphincter muscles with 85 per cent of continence, without division, 95 per cent. A mortality of 6.2 per cent was reported, 14 deaths in 223 patients. The rates of survival were 58.6 per cent for three years and 50.0 per cent for five years. Impotence by this type of operation was reduced, as compared to the Miles abdominoperineal resection, it was 55.5 per cent when the sphincters were divided and 8.3 per cent when the sphincters were not divided.

Paul C. Blaisdell, Pasadena, Calif. Unique Behavior of the Healing Open Pilonidal Wound and Clinical Complications—The characteristics of the different components of the healing of pilonidal wound were discussed. The causes of delayed healing, their prevention and treatment were included. A simple and effective acceleration of average healing time, the unrecognized relation of delayed healing and recurrence, and the misunderstood role of injection were discussed. No comparative evaluation of the method was attempted, the aim of the paper was to clarify basic facts related to the problem.

Friday, July 5 Symposium on Wound Management

John D. Stewart, Buffalo, N. Y. Wound Shock—The clinical picture of wound shock as seen in the gravely wounded battle casualty, was discussed along with the causative factors. Reduction in blood volume per se, due to hemorrhage and loss of blood, was felt to be of major importance. An analysis and the significance of metabolic disturbances, including anemia and hypoproteinemia often appearing after recovery from wound shock were elaborated upon.

Robert Rustigian and Arthur Cirpriani, United States Army Sanitary Corps **Bacteriology of Open Wounds**—Two hundred fourteen bacteria comprising the complex floras of twenty seven septic and nine contaminated war wounds were differentiated functionally as (1) toxigenic and/or invasive, (2) proteolytic, and (3) commensals. The first group, the true pathogens, included *Staphylococcus aureus*, *Streptococcus pyogenes*, and gas gangrene bacilli. The proteolytic bacteria were considered as wound pathogens and included *Clostridium sporogenes*, *Clostridium putrifans* group, *Clostridium bifermentans*, *Proteus*, *Pseudomonas*, *Bacterium melanogenum*, and certain anaerobic streptococci. The predominant commensal bacteria were the enteric and undifferentiated streptococci, micrococci, and coliform bacteria.

Howard E. Snyder, Winfield, Kan. **Blood Replacement in Wound Management**—Adequate and timely blood replacement was a very important factor in the reduced mortality of battle casualties admitted to hospitals in World War II. Clinical observation, followed and substantiated by laboratory investigation, proved that whole blood loss rather than plasma was the cause of reduced blood volume. The replacement by whole blood was found essential to the successful management of cases in severe shock. It not only reduced the mortality rate but also decreased the morbidity, hastened convalescence, and permitted extensive early reparative surgery. In forward hospitals, banked blood titrated for anti A and anti B agglutinogens was found most satisfactory.

Champ Lyons, New Orleans, La. **The Role of Chemotherapy in Wound Management**—The open wound is vulnerable to two types of bacterial inflammation: (1) invasive infection and (2) wound suppuration. The former is due to hemolytic streptococcus, toxigenic clostridia, or staphylococcus. The process of suppuration is locally necrotizing and gives rise to nonspecific toxemia. It was reported that proteolytic bacteria, lacking in invasive attributes, are frequently insensitive to available antibacteriocidal drugs. They are designated as "wound pathogens." "True pathogens" are both invasive and proteolytic. Chemotherapy by the systemic route controls only impending or established invasive infection. It was stressed that no method of chemotherapy can substitute for technical and surgical management of wound suppuration.

Francis B. Berry, New York, N. Y. **Surgical Principles in Wound Management**—Wound healing and management from the historical standpoint were discussed. The normal processes of healing in the various tissues were elaborated upon, stressing the importance of local and systemic factors. The local factors included devitalized tissue, sequestrums, foreign bodies, blood supply and vascularity, dead spaces, and infection. The systemic factors included age, hydration, protein balance, nutrition, anoxia and anemia, circulation, and vitamins. The role of antiseptics and bacteriostatic agents and wound stimulants were discussed along with the preparation of the wound and the handling of tissues.

Ralph Adams and Bernard J. Ficarra, Boston, Mass. **An Appraisal of Surgery in the Treatment of Bronchiectasis**—The surgical treatment in a group of fifty consecutive cases of bronchiectasis carried out during the five-year period ended Aug. 31, 1945, was reported. Clinical, pathologic, and psychologic manifestations of the disease, and important principles and details of surgical treatment, were given. Eight patients developed postoperative complications, five empyema, two bronchopulmonary fistulas, and one thrombophlebitis. Forty-two patients were reported cured. The mortality rate was zero.



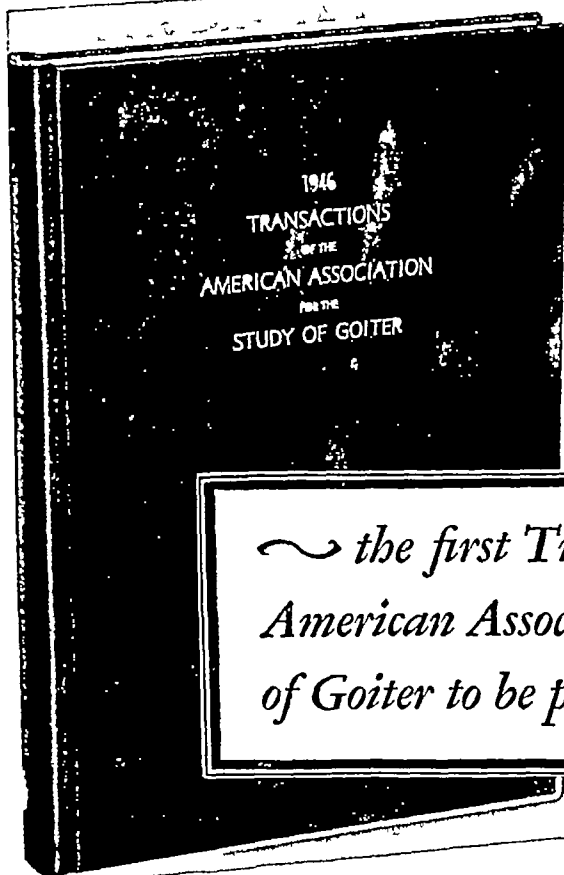
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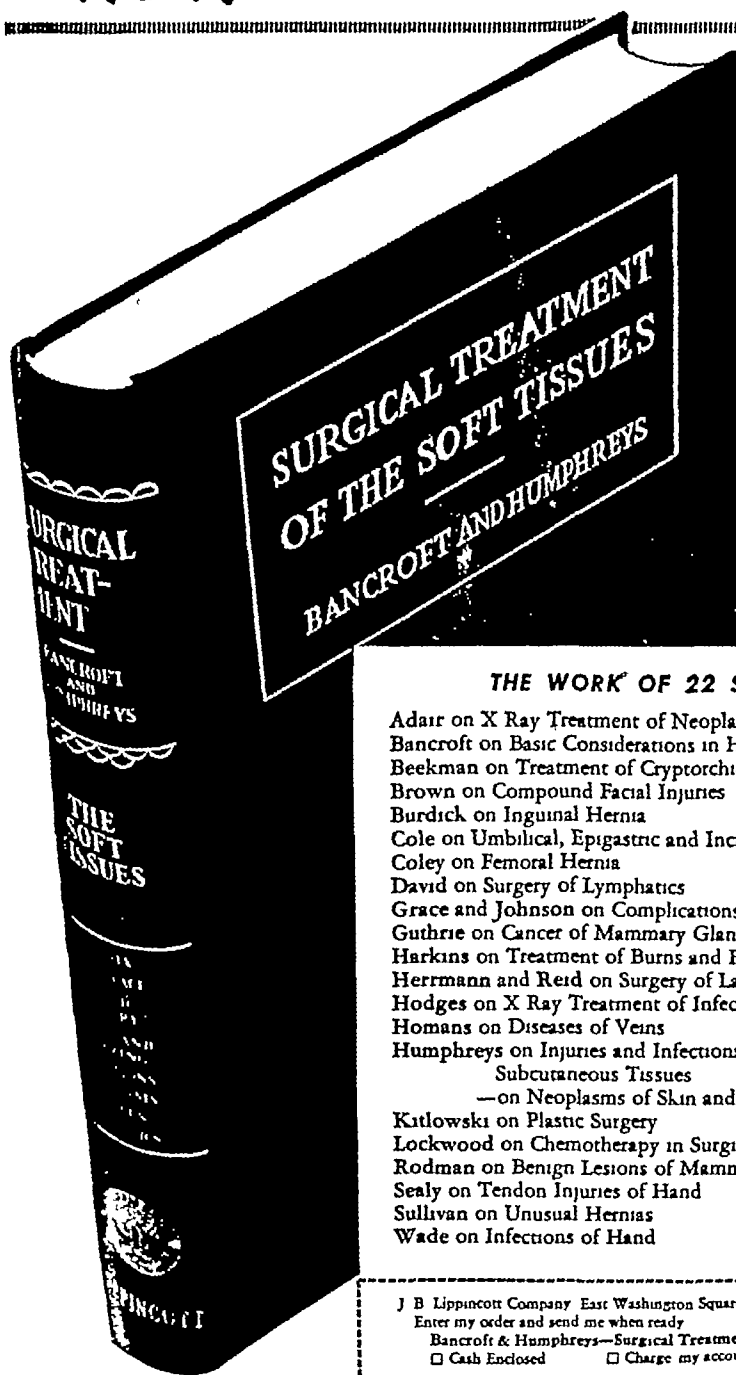
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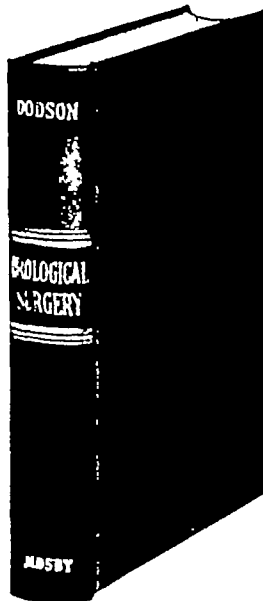
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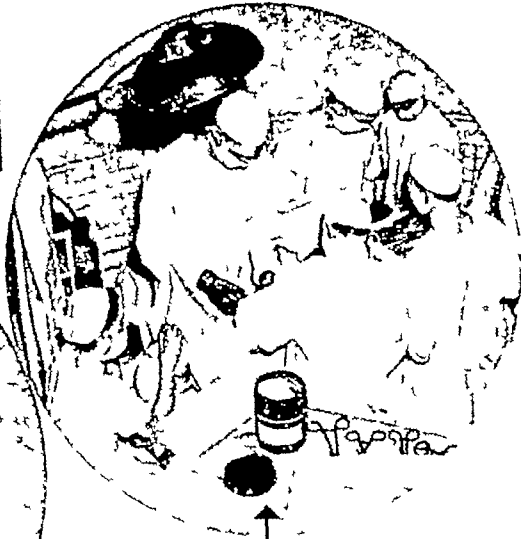
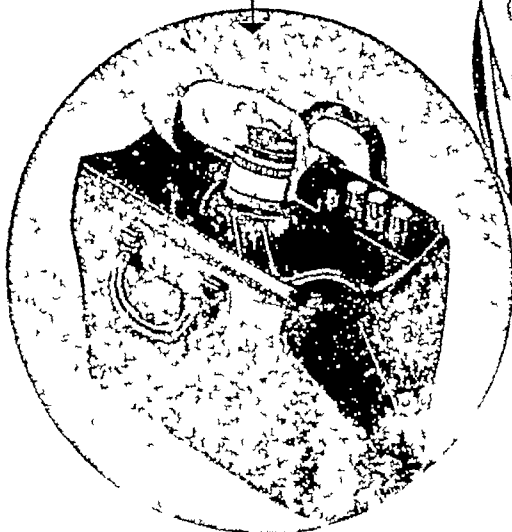
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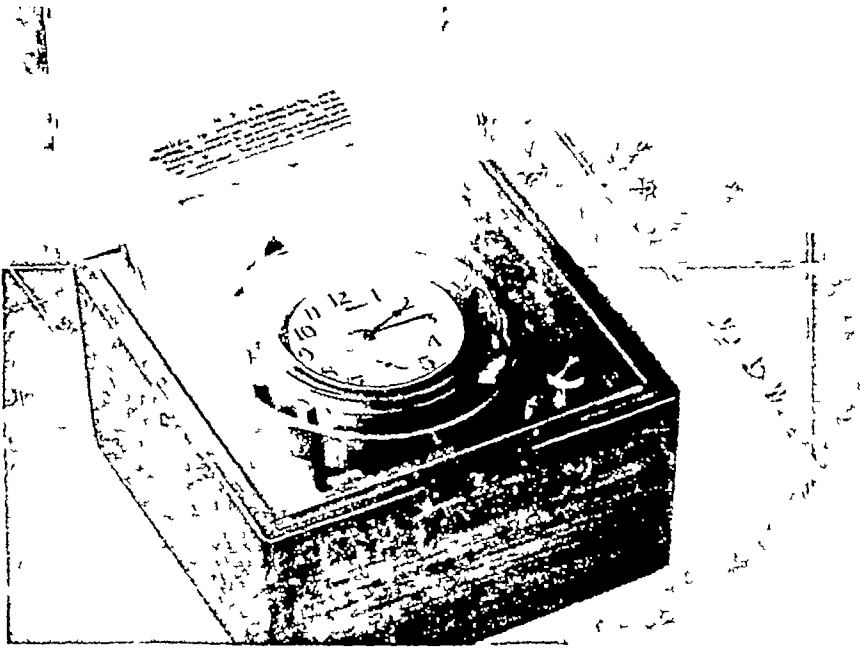


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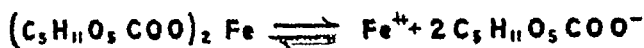
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2. Editorial, J.A.M.A. 127:1054, 1945.
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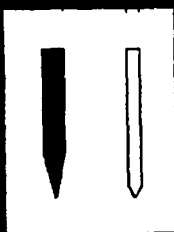
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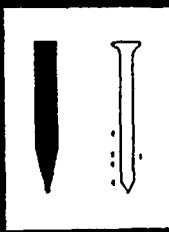
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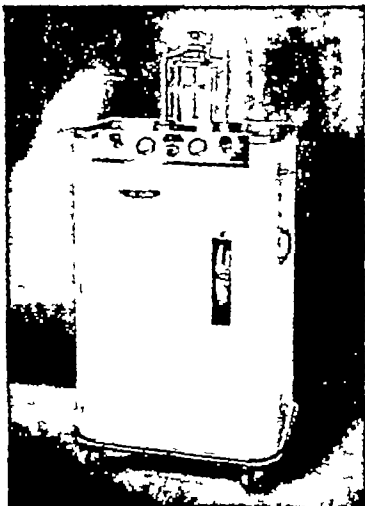
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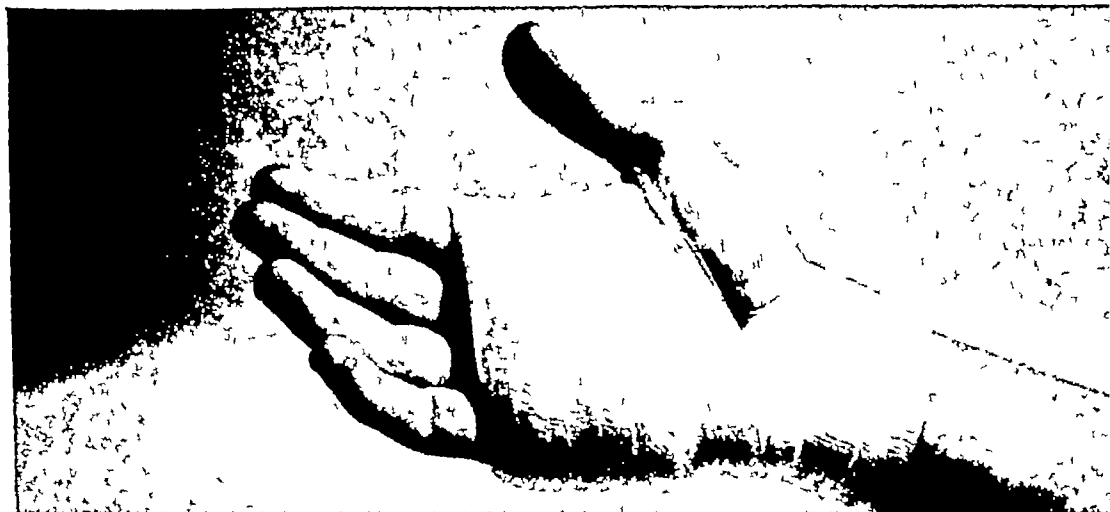
METICULOUS attention to details in the preoperative and post-operative care of patients, through innumerable small maneuvers before, but especially during and after operation, may avert disaster or shorten convalescence, if neglected, they may cost a patient's life. Yet textbooks of surgery rarely mention such details, and most of your surgeons must learn them for themselves, often from bitter experience. This book gives the details necessary to the adequate care of neurosurgical patients, and is written in the hope that the information here set down which is based on the author's own experience since 1911, may be of benefit both to house officers generally, and to the rapidly growing number of young neurosurgeons especially who are preparing themselves to enter this field. It is also of value to experienced neurological surgeons. Typical neurosurgical operations have been described in great detail, and have been illustrated profusely by drawings as well as by case histories, including subsequent treatment with the reasons for each step. The operative procedures, therefore, should be more vivid and more clearly understood.



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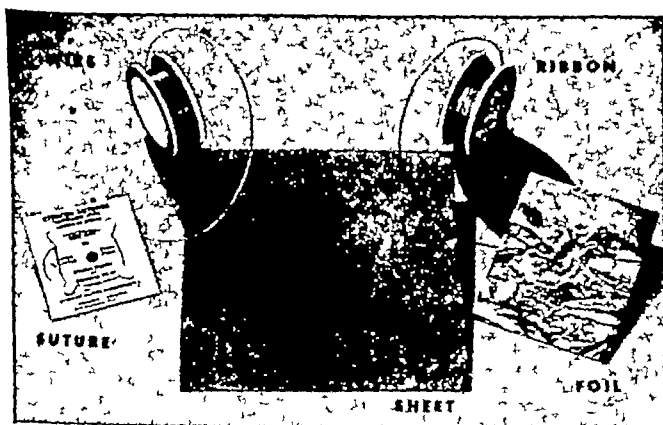
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John J. Morton

SURGERY

VOL 20

NOVEMBER, 1946

No 5

John J. Morton Birthday Number

PREFATORY NOTE TO JOHN J. MORTON BIRTHDAY VOLUME

THIS number of SURGERY, designated to honor the sixtieth birthday of John J. Morton, Professor of Surgery and Surgical Chief of the School of Medicine and Dentistry and the Strong Memorial and Municipal Hospitals, has the enthusiastic support of all his friends and associates in Rochester and elsewhere. As it was not possible for me to submit a suitable paper at this date, I was given the opportunity of writing this prefatory note. It is a great personal pleasure to participate and express my admiration for my long-time friend and colleague. His department is conspicuous not only in clinical service and student instruction but in the training of young surgeons and the pursuit of basic research. It has been my good fortune on various occasions to address surgical meetings on the subjects of hemoglobin production in anemia, intestinal obstruction and the related intoxication, shock produced experimentally in various ways, and the usefulness and production of plasma protein under a variety of conditions. Cooperation between pathology and various departments of surgery has been a pleasant stimulus in Rochester and elsewhere. Joint problems between surgical and preclinical departments have always interested John Morton and his surgical associates. If the wishes of his friends have any influence, John Morton will enjoy many more years of distinguished service in his field—the science and art of surgery.

—George H. Whipple, M.D.

Rochester, N. Y.

THE DEVELOPMENT OF THE GRADUATE TRAINING PROGRAM IN SURGERY

SAMUEL C HARVEY, M D , NEW HAVEN, CONN

(From the Department of Surgery, Yale University School of Medicine)

SURGERY is at the moment in the midst of a trying and even critical period, where on the one hand there is more knowledge to be learned and greater occasion for the perfection of skills, and on the other, a damming back of young prospective surgeons who, now being released from the Armed Forces, are seeking opportunities to receive an adequate training in this field. Many who previously would not have considered undertaking the arduous and time-consuming work entailed, stimulated in part by their experiences in the Armed Forces and by the benefits available for education of the veteran, are seeking adequate opportunities for graduate training in surgery. There is a grave danger that in response to this demand the training will be abbreviated in time and depreciated in quality to a degree that will render it of limited value and largely fictitious. If this occurs, it will be deplorable for not only will adequate standards be difficult to retrieve, but there will be foisted upon the public a generation of inadequate surgeons.

Therefore, it would seem not inappropriate in this *Festschrift* in honor of the head of a university clinic in surgery which has exemplified the training of surgeons, that a brief consideration of the history of the graduate training of the surgeon be given.

Before the development of anesthesia and asepsis, surgery was taught in the schools of medicine under the concept that on graduation the student would then be prepared to practice it, an assumption that still obtains in most of our state laws for licensure. In an occasional hospital the novitiate in medicine served an additional year as an intern, but the great majority entered into practice. A few spent a *Wanderjahr* in Germany, Paris, London, or Edinburgh, or became assistants at home to some senior men in their practices. These experiences were in some instances of great value, but frequently only casual and served as generally informative rather than as a specific training.

With the rapid increase in the size and number of hospitals that developed because of the evolution of medicine and surgery toward the close of the nineteenth century, the introduction of a house staff became an obvious advantage both to these institutions and to the newly fledged graduate of the medical school. The internship of from one to two years was a relatively common arrangement, usually rotating through all divisions, but in some instances unbalanced in favor of medicine or surgery. From this it was the custom to start in general practice, building up from one's own clientele or by virtue of being a junior attendant at some hospital, gaining a reputation as a surgeon.

The experience so acquired was usually tenuous and without supervision, frequently at the cost of the patient. Now and then, a continuous association with an able elder surgeon who had a feeling of responsibility for the education of the younger man and with a willingness to "turn down" work to him provided an excellent training. Such an intimate and prolonged contact was rare in the relatively fleeting experience of the internship, and unusual in the customary relationships of the attending staff.

Moreover, as long as surgery was limited in its scope only a few large centers of population provided enough work to justify a person in confining himself to this field of activity, elsewhere, general practice formed the bulk of one's practice, and the general practitioner did what surgery came his way, sometimes with little enthusiasm and less skill. With the rapid widening of the field toward the close of the nineteenth century this situation changed, for not only did many more opportunities for the judicious use of surgery develop, but the breadth and depth of knowledge involved and the technical skills required increased in even greater proportion. It no longer sufficed for one to do surgery vicariously, if he were to do it well, it became important for him to receive an early and intensive training under proper auspices in order that he might adequately take over these increased responsibilities. At the same time the number of opportunities in practice for men so trained increased tremendously.

Naturally, this was felt first in the larger hospitals where this work accumulated, for it no longer was possible for the detailed study and care including the operative procedures to be carried out in the home as was to a great degree formerly done. Particularly was this true in those institutions associated with schools of medicine where teaching was carried on. Whereas formerly surgery because of its limited scope could be taught adequately in the undergraduate years, it now became apparent, as in other special fields, that only a general background and the knowledge that the reasonably well-informed physician needed to have at his command could be so supplied. Further study and training were required after graduation, and to such an extent that they could not be provided by the haphazard methods that formerly obtained. This was first realized in those places where the association of the hospital with the school of medicine of a university was intimate. It was under these circumstances that much of the expansion of the teaching of surgery took place, and the adequate graduate training of the surgeon became established.

This transformation occurred most remarkably in Germany, and it was not without reason that so many surgeons of the previous generation went there for graduate training. A knowledge of the German literature became essential to him who aspired to be a surgeon of the first rank. There for many generations medicine had been an integral part of the university which accepted not only the prestige entailed in this association, but also the responsibilities of proper maintenance, financial and scholastic. Of the great development of science which took place in Germany during the nineteenth century, medicine was an integral part, and inferior to none. The clinical departments were not only tolerated in the great hospitals but were in control as far as the profes-

sional activities were concerned. It is there that Halsted¹ looked for the example of adequate graduate training, since other countries lagged far behind during this time.*

In the United States the schools of medicine were "proprietary," that is to say, survived upon the fees derived from students and the goodwill of physicians who valued highly the prestige of being professors. Many of these schools had a titular affiliation with a "college," whose name appeared on the diploma by virtue of a franchise from the state to grant degrees, it thereby attaining the semblance of a university, only in rare instances did it exert control or assume responsibility, financial or otherwise, for the school of medicine, and even then its influence was halfhearted and its support penurious†

The first notable change for the better came with the institution of the Johns Hopkins Medical School, an integral and important unit of the university, and with its affiliation with the Johns Hopkins Hospital. All the major departments were pitched at a university level, including those having to do with medicine and surgery, and the function of teaching had a high priority. In surgery Halsted instituted the German plan, as he called it, the essential figure in it being a house surgeon, first assistant, or chief of house staff, who was selected from resident assistants and remained at this post until called elsewhere or until he decided to enter private practice. This individual came to be known as the resident in surgery and this type of training as the resident system. The introduction of it into surgical teaching in this country was one of Halsted's important contributions.

As the resident matured, and in Halsted's clinic he usually stayed on for several years, he became capable of greater responsibility and was granted it as time went by. In this way he gained an unusual and concentrated experience in a relatively short period. The success of this program over the years

* Why was Germany the country first to adopt antiseptic surgery? Why did almost every surgeon in every German university eagerly embrace Lister's system almost at the same moment and as soon as it was clearly presented? The answers to these questions are I believe to be sought mainly in the character of the scientific training of surgeons in Germany.

Not only the first assistants but all the members of the surgical staff of one of the great university clinics in Germany enjoy almost ideal facilities for learning surgery and for prosecuting researches. The amount of clinical material is great. The operative work begins early in the morning and often does not cease till late in the afternoon. The out-patient department is controlled by the chief surgeon and is conducted by his assistants; a patient when discharged is consequently not referred to some dispensary or other and lost sight of. The pathological material obtained at operation is carefully worked up in the special laboratories for surgery and, if need be, is preserved in the museum which should always be an important feature of the surgical department of university. Every facility and the greatest encouragement is given each member of the staff to do work of research.

In each university the chair has its imperishable traditions. Its long line of famous surgeons whose names are cherished and revered for their services to science, to their universities to their country and to their fellows. In the nineteenth century to mention only some of those who have passed to the majority in the University of Berlin were v. Graefe, Dieffenbach, v. Langenbeck, in Vienna Vincenz v. Kern, Billroth, Albert, in Heidelberg v. Chelius, Carl Otto Weber, Gustav Simon. In my student days there were in Leipzig, Thiersch, in Halle, v. Volkmann, in Bonn Busch, in Tübingen Victor v. Bruns, in Munich v. Nussbaum, in Strasbourg Lücke, men of great renown every one. To enroll one's name with such as these to inherit something of their skill, their knowledge, their zeal, their honor, their sense of duty is not this worth while? The professor of surgery in Germany is usually a man of great influence and power. His affiliations, his responsibilities, his knowledge of surgery and the allied sciences, and often of art of music, of literature and of the world's affairs, produce a type of man which his country may well contemplate with pride.¹

† It may be that the rise and multiplication of proprietary schools of medicine without organic connection with a university was a necessary incident in the rapid growth of a new country but it is absurd to expect them to yield results in the education of physicians and in the advancement of knowledge comparable with those of the well-supported medical departments of European universities. It is difficult to free either the educated public or our universities from the reproach that they remained so long indifferent to the needs of higher medical education.¹

of Halsted's life was demonstrated by the number of chairs of surgery filled by his pupils, so much was this the case that they and in turn their disciples came to be recognized as of the "Halsted School," and wherever they went, they carried with them the concept of the resident system*. It should be added, however, for the sake of historical accuracy, that its acceptance in other than the clinics of Halsted's pupils was sharply opposed, partly because of misunderstanding and partly because the formation of a resident house staff was thought to interfere with the prerogatives of the senior attending staff. Gradually during the past quarter of a century it became recognized that house officers of experience beyond that of the intern were of great assistance to the attending surgeons. Coupled with the increasing awareness of the necessity for the better training of surgeons, there developed more widely an acceptance of the resident system for the postgraduate training of the surgeon.

Meanwhile, two other moves of a noteworthy nature were directed toward this objective. In 1910 the Clinical Congress of Surgeons was formed and in 1913 the American College of Surgeons. Franklin Martin was largely responsible for both of these moves, but A. J. Ochsner² in an address at the Second Annual Meeting of the Congress in 1911 outlined an educational program for surgeons.

This was in essence the projection on a grand scale, into the years after graduation, of the methods of teaching surgery current in the schools of medicine. In the larger centers of population where sufficient hospital and clinical material was available, meetings were to be held, consisting in part of operative clinics, and in part of papers and addresses by distinguished surgeons. These sessions have been continued until the present time and have served useful purposes, but as a method of graduate training in surgery they are outmoded.

In 1917 the University of Minnesota and the Mayo Clinic merged their respective resources for training at the graduate level. Lyon³ in his presentation of the program frankly termed it experimental. In 1921, Wilson⁴ reported upon this, reviewing the experience and laying down the fundamental prin-

*It was our intention originally to adopt as closely as feasible the German plan, which in the main is the same for all the principal clinics of the German universities. The house surgeon, or first assistant as he is called in Germany, is selected after several years of service from a number of well-tried assistants. There is no regular advancement from the bottom to the top of the staff of resident assistants. Only a small proportion of these venture to entertain the hope of becoming first assistant. Occasionally an assistant from another clinic may immediately or almost at once after transfer succeed to this position over the heads of those who have served many years. This admirable system which undoubtedly has its disadvantages is possible only in a country where like conditions prevail and a close affiliation exists between the universities or where some great inducement exists for the making of assistants of the highest possible order. The professor of surgery or the surgical chief desires to secure as his first assistant or chief of staff a man of great promise not only because of the obvious immediate advantage to the clinic but because such an assistant is likely to have tendered him ultimately the chair of surgery in some smaller university. It is a matter of great satisfaction and pride to a professor of surgery to have supplied from his staff one or more university chairs.

We need a system and we shall surely have it which will produce not only surgeons but surgeons of the highest type men who will stimulate the first youths of our country to study surgery and to devote their energies and their lives to raising the standard of surgical science. Reforms the need of which must be apparent to every teacher of surgery in this country must come on the side both of the hospital and of the university and it is natural to look to our new institutions unhampered by traditions and provided with adequate endowment for the inception of such reforms. It is eminently desirable if not absolutely essential that the medical school should control a hospital of its own. There should be such an organization of the hospital staff as I have indicated providing the requisite opportunities for the prolonged and thorough training of those preparing for the higher careers in medicine and surgery and permitting the establishment of close and mutually stimulating relations between chief and assistants.⁵

ciples in a very sound discussion. The picture, which he so well described, of the obvious inadequacy of many of the applicants for such training, and of the further inadequacy of those accepted as demonstrated during the course, is as true today as then.

The Council on Medical Education and Hospitals of the American Medical Association considered the matter in 1920 and 1921, and Frazier and Lewis⁵ formulated a general report which was published in the latter year, sound principles were again laid down, which were amplified in an address by George Muller⁶ in 1921. This involved the setting up of a graduate school with scheduled continuous teaching using the methods and organization of the undergraduate school for the purpose of training in the divisions of medicine and surgery. The introductory year with its intensive review and amplification of those subjects of importance to the surgeon, which are taught inadequately in the undergraduate years, has proved useful, particularly for those men who have been out of school for some time and who wish to specialize. The program recognized the necessity of following this with extensive experience in residencies in hospitals adequate for this purpose, which, however, have not been readily available. On the whole, such graduate schools have been only of limited value and have tended to suffer from the lack of intimate support by association with other educational institutions. They have remained in most instances essentially proprietary in character and thereby have incurred the disadvantages of the proprietary medical school. Only when adequately endowed and intimately integrated with university schools of medicine will this approach prove satisfactory, and then only when the opportunity for learning lies in the clinic and its ancillary laboratory facilities rather than in the lecture rooms.*

Meanwhile during the early 30's in the nonoperative as well as the operative divisions of medicine there had developed rather generally a feeling that some mechanism must be devised for the recognition of those specialists who were competent, in the hope that this would lead to proper graduate training and would discourage the setting up as specialists of men inadequately prepared and incompetent. From this came the formation of specialty boards in all the well-recognized specialties, and the co-ordination of their activities with those of the American Medical Association through the Council on Medical Education and Hospitals. The American Board of Surgery was one of the last to be instituted probably because the American College of Surgeons was already engaged in the certification of surgeons and an educational program which by many was considered sufficient. As a result of discussions in the American Surgical Association and other senior surgical societies, and with the cooperation of the American College of Surgeons and the American Medical Association, the American Board of Surgery was finally instituted in 1937.

*It is perhaps of significance that in Vol 13 of the Index Catalogue of the Library of the Surgeon-Generals Office Series I published in 1892 there is no reference to the teaching of surgery while in Vol 17 of Series II, published in 1912 there are many references but nearly all concerned with undergraduate instruction a notable exception being Halsted's address previously cited. In Vol 9 of Series III, published in 1931 there were on the whole a much smaller number of papers cited but among these were the notable contributions, with specific reference to postgraduate training of A. J. Ochsner, George Muller and L. B. Wilson.

Its organization followed the pattern of previously formed specialty boards, the members of it being composed of representatives of the following national surgical associations American Surgical Association, Surgical Section of the American Medical Association, American College of Surgeons, and of the larger of the societies representing geographical areas, namely, the Southern Surgical Association, the Western Surgical Association, the Pacific Coast Surgical Association, and the New England Surgical Society

In order for the Board to accomplish its purposes it was necessary for it to establish an examining procedure, and to define within rather broad limits, with allowance for justifiable elasticity, that which might be considered the minimum of an adequate training in surgery This latter was first based on an estimate of the extent of the knowledge and the degree of skill which should be expected of a certified surgeon and then the necessary minimal time and the methods for acquiring these designated in a general statement⁷

The immediate and continuing recognition of this Board as authoritative in its field has been remarkable Many hospitals and other organizations have used its certification as a basis for the selection of surgeons, and the program of training required for admission to examination has been accepted as reasonable and fair not only by the surgical profession as represented in its constituent societies, but also, and this is even more important, by those undertaking to become surgeons The present-day graduate desiring to perfect himself in surgery is willing to spend the necessary time and effort in order to meet these requirements as shown by the large number of men who are asking the Board to advise them as to where they can obtain this training However, the provision of an adequate number of bona fide residencies, while on paper apparently satisfactory, is in fact in a state of confusion The graduate intending to perfect himself in surgery wishes to be assured that the residency he undertakes will be considered to have met in the specific instance the requirements of the Board This is a natural and justifiable query, for no one wishes to embark upon a five-year program without knowing quite definitely that it meets the minimal requirements for eligibility for examination.

However, the Board has not undertaken, and cannot well do so, the certification of residencies It remains for the prospective student to evaluate the opportunities available The information upon which he must depend is limited The method of validating residencies employed by the Council and the College is for the most part a survey of the physical facilities and a statement regarding proper organization These are certainly minimal requirements but do not in themselves, and automatically, render the institution an adequate one for graduate training, nor, unfortunately, does the request of the hospital for validation indicate that it has a proper understanding of the problem or even in some instances is it of sufficient assurance that it is acting in good faith

Most institutions have become aware within recent years that a graded house staff in which there are men of two, three, or four years' experience is of inestimable value to both the administrative and the professional staffs to say nothing of the welfare of the patients It has also become common knowl

edge that if an institution can be certified for a graduate training program, this medical personnel can be obtained at little if any additional cost above that of board and lodging. The fictitious junior and senior residencies of the 9-9-9 program indicate the avidity with which hospitals under the guise of a training program may organize the house staff for service purposes having but little to do with education, and, in fact, this was set up at the instigation of the hospitals in order that they might obtain a necessary minimum of interns for the care of patients. Nor is the exploitation of the desire of the student for adequate training in the special fields confined to institutions. It also, in some instances, may be used by the surgeon as a method of obtaining an assistant who will relieve him of routine duties requiring a modicum of skill, the student receiving in return but little of educational value. This abuse may be particularly pernicious where the so-called residency is entirely or in greater part concerned with the care of private patients. The increasing responsibility given the surgeon in training, commensurate with his developing experience and competence, is at times sorely lacking under these circumstances. He continues to function at the level of an intern throughout his training, at no time having even a fraction of the responsibility which he will immediately be presumed capable of assuming when certified.

It is obvious that the certification for residencies of some hospitals is made only on the basis of adequate physical facilities, an over-all census of beds available, and a tentative agreement by the administration to the plan of graduate training recommended by the College. It is not apparent that the competency and interest of the surgeons to carry out this training have been adequately evaluated, nor that a proper organization of the clinical facilities has been agreed upon by them. The situation in some instances is analogous to that of the opening of a new school for which the buildings and the materials necessary for teaching are at hand, but a competent teaching staff not organized or assembled, this being left to improvisation after the students have been admitted. It still remains true that a competent instructor in second-rate facilities is more effective than an incompetent one with the best of material aids, although neither alternative is desirable.

It is then necessary that the prospective surgeon be certain before accepting institutions for training that there is a proper organization of the clinical facilities and that competent professional personnel is available, willingly prepared to devote itself to the training plan.

The general program for graduate training as described in the *Bulletin of the American College of Surgeons*,⁸ as well as the evaluation of the physical and ancillary facilities, is valuable information and should be studied with the prospective institution in mind. In addition, one needs to know what proportion of the beds is available for the training of the surgeon, and that during his residency he will have a sufficient number of patients for whom he is directly responsible throughout their stay, including the operative procedure. He should also assure himself that there is a director of the program, immediately in charge of it, who is an accredited surgeon. This should be true also of his senior assistants. The director must have a continuous control throughout the year.

of the clinical facilities used in this training program. Moreover, the intern should be certain that there will be sufficient stability of the personnel involved over the proposed period of his training so that policies and procedures will not vary year by year. Finally, if it is possible, the prospective student should ascertain the fidelity with which the program is being carried out.

The responsibility rests in the first instance upon the student, for no agency can guarantee that a certain program or a certain institution will make a competent surgeon out of him. Whether or not he has the fundamental requisites which make him suitable for this undertaking is a question he himself must answer. Integrity of character is a first requisite, for the surgeon must assume responsibilities and make decisions which test the very sinews of honesty and straight thinking. A second is that he have a better than average intellectual equipment as shown by his previous educational experience, for he must acquire and retain, and continue to do so throughout his professional life, a profound and critical knowledge of his special field, applicable in a moment to a decision that may spell life or death. With this he must be capable of developing the particular skills of the surgeon necessary for its application. A third requisite, and this may be used as a measure of the first two, is that he choose surgery because of so consuming an interest that he would still undertake the necessary training were the emoluments arising from it as modest as they may well be in any particular instance. The answers to these questions only he can give, and he should with a sense of grave responsibility.

An even greater responsibility rests upon those institutions initiating graduate training. They have a great opportunity to carry out an educational project at a level where it is most interesting to teacher and student alike. The teachers must be certain first that they themselves are qualified for this task and completely willing to give it first place in their activities, and those certifying institutions for residencies have the responsibility of making certain that the professional personnel as well as the physical facilities are adequate for the task in hand.

Lastly, the examining board in surgery, which does not and cannot specifically certify institutions as competent for graduate training, must make certain with each applicant for examination that he has spent the necessary time under appropriate circumstances as defined in general by it. The purpose of this is not primarily to ascertain the fitness of the candidate for examination, although it is a futile performance for both examiner and examinee alike where it is obvious that the preparation is inadequate, but rather to make reasonably sure that he has been exposed to an experience which should have given him the opportunity to become a competent surgeon. Having done this, then the examination itself must be searching and thorough in order that, in so far as this procedure can do so, it be made certain that the student has satisfactorily availed himself of the opportunity. The end in view is not in itself the awarding of a diploma, but the seeing to it that this accolade comes to rest only on the shoulders of men of integrity and of knowledge and skill in the field of surgery.

The generation of surgeons trained subsequent to World War I amply proved the worth of intensive graduate education in this field. It is of the utmost importance that there be now no lowering of standards, no retrogression, for there is a common understanding of what is required and only an earnest effort is necessary to see to it that the coming generation is at least equally well prepared for whatever may be in store for it.

REFERENCES

- 1 Halsted, William Stewart The Training of the Surgeon, Johns Hopkins Hosp Bull 15 267 275, 1904
- Surgical Papers, vol 2, Baltimore, 1924, The Johns Hopkins Press, pp 512 531
- 2 Ochsner, A J Co ordination of Undergraduate and Postgraduate Teaching of Clinical Surgerv, With a View to Securing Efficiency, Surg, Gynec & Obst 14 451 456, 1912
- 3 Lyon, E P Graduate Education in the Clinical Branches, and the Minnesota Experiment, J A M A 69 1307, 1917
- 4 Wilson, Louis B Teaching the Fundamentals of Surgery From the Point of View of the Graduate School, J A. M. A 79 120 125, 1922
- 5 Frazier, C H, and Lewis, Dean Report of the Committee on Postgraduate Instruction in Surgery, J A. M. A 76 732, 1921
- 6 Muller, George P Graduate Instruction in Surgerv, J A. M. A 77 503 506, 1921
- 7 The American Board of Surgery, Booklet of Information, Philadelphia, June, 1945
- 8 Special Bulletin of the American College of Surgeons, Chicago, September, 1945

EXPERIENCES WITH CORTICAL EXCISIONS FOR THE RELIEF OF INTRACTABLE PAIN IN THE EXTREMITIES

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THE problem of intractable pain has been attacked by the neurosurgeon in various ways according to the type and severity of the pain and according to its seat of origin. Leaving aside such conditions as trigeminal and other neuralgias, for the most part, in civil life, intractable pain is due to pressure upon nerves or nerve roots by inoperable malignant disease and, more rarely, to irritation of nerve roots following spinal trauma or to the syndrome designated by Weir Mitchell as causalgia. The latter condition has come to the fore during the war years, together with the phenomenon of pain associated with a phantom limb after amputation. An extensive literature has developed during the past few years devoted to the treatment of causalgia and postamputation pain, and the present status of the situation was well summarized by White¹ in 1944. In this article White described the usual procedures, such as single excision of a neuroma, sympathectomy and cordotomy, outlining the possibilities of relief from each type of procedure. He further cited the possible value of extirpation of the postcentral cortex for these painful conditions, and quoted a personal communication from Mahoney in which such a cortical excision was successful for intractable pain in a phantom extremity.

Mahoney² has since reported the case referred to by White, and in so far as I can discover, this is the only case on record in which excision of the postcentral cortex has been performed for any type of pain. In the case cited by Mahoney, incapacitating pain was present in two phantom fingers which had been accidentally amputated. After extirpation of an area in the postcentral cortex, stimulation of which produced sensation in the affected fingers, there was disappearance of the phantom and of the pain, neither of which had reappeared after a lapse of two years.

Because of the encouraging result reported by Mahoney, it was decided to apply this method of treatment in two patients who had been unrelieved by other forms of operative interference for painful extremities, and in two other patients whose pain was obviously of cortical or thalamic origin and, therefore, presumably would have been uninfluenced by any type of procedure on the spinothalamic tract or the sympathetic system.

In the first two patients the results have been highly disappointing, but in the two with central pain an excellent measure of relief was obtained.

The first of the patients was a man who had had both arms amputated above the wrists.

followed shortly by pain starting in the thumb and index finger of the right hand. He was admitted to another hospital where a lumbar puncture and spinogram was performed in November, 1943. There was no subarachnoid block and the total protein of the fluid was 21 mg per cent. A cervical laminectomy was carried out in December, 1943, and there was said to have been "angulation of the fifth cervical spinal nerve root." The intervertebral foramen at this site was "enlarged and the root straightened." There was said to have been "very minimal protrusion of the intervertebral disk." The dura was left open over the fourth to the sixth cervical area.

At the time the patient came under observation he was apparently suffering excruciating pain in the right hand and arm, and also had a lesser degree of pain down the left arm. He said that the pain had become much worse since the laminectomy. Both hands were reddened and shiny, this being more pronounced on the right. There was atrophy of the intrinsic muscles of the hands, which the patient said had started about one year previously. The right thumb was excessively tender, the ring and little fingers were hypersensitive. The index and middle fingers were rather insensitive. Motions of the right arm were greatly limited throughout at the shoulder, elbow, and wrist, with almost no motion of the fingers. Movements of the left arm and hand were quite good but painful. There was no hypersensitivity of the left hand. The biceps reflex was absent on the right and present on the left. The triceps and periosteoradial reflexes were present and equal on either side.

The patient had had elsewhere a procaine block of the cervical sympathetic without relief of the pain, and because no other measures had been of benefit he had become addicted to morphine.

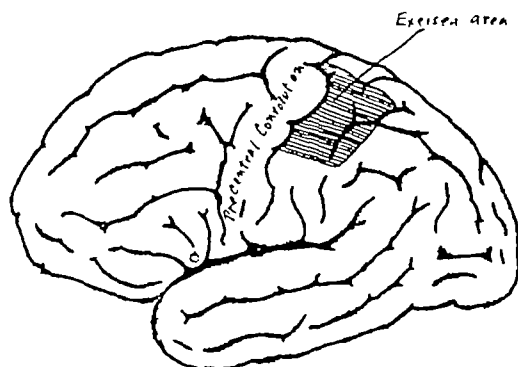


Fig 3—Case 2 A F

Operation 1—March 5, 1945, a reexploration of the cervical cord was carried out and a large, hard protuberance was removed anterior to the cord at the sixth cervical level. This protuberance had likewise compressed the sixth cervical nerve root. There was a great deal of new bone formation at the site of the intervertebral foramen which had been enlarged at the operation done elsewhere. Fibrin foam was placed over the raw area of bone removal at the close of the operation. Following this procedure he appeared to be somewhat relieved for about two weeks and required considerably less medication. However, at the end of this time the pain returned with its former severity.

Operation 2—April 21, 1945, under procaine anesthesia a left central craniotomy was performed and the motor area for the right face and right arm delineated with the galvanic current. Two convulsive seizures were initiated by the stimulations and the patient's cooperation thereafter was not good enough to outline the pain centers. For this reason the convolution just posterior to the motor arm area was excised, going upward to the leg area and inferiorly to the face center (Fig 3). The excision was carried to a depth of 2 cm and tissue was excised anteriorly to the point from which jerking of the right arm and shoulder took place as the electric current was being used.

The pathologic report on the specimen was negative cerebral tissue.

Postoperative Course—Immediately after the operation the patient was again given narcotics, but was gradually put on sterile hypodermics and seemed to get along just as well as far as could be told, although he would not admit it. On the other hand, he began to complain of increasing pain in the left hand and arm, and morphine had to be resumed for this.

Sensory examination of the hand and arm was always unsatisfactory after the cortical excision because of the patient's variable responses. About all that can be said is that there appeared to be some general lessening of pain sensation (pinprick) throughout the whole right hand and arm as compared to the left.

When questioned carefully as to the pain in the right hand, however, he admitted considerable relief from the original pain, although he could not put the differentiation into words. He was finally discharged to another hospital where his condition remained unchanged at the last report in December, 1945.

Comment—Here again, the psychic trauma of two serious operations without relief, together with the complication of morphine addiction, doubtless militated against a favorable result, but for this patient also there was the desire to leave no stone unturned which offered any prospect of relief. The type of pain from which he suffered was consistent with a true causalgia.

The following two patients whose histories are summarized had central pain in the contralateral extremities to the cerebral lesions. In both there was very considerable relief following the operations.

CASE 3—F. J. C., a 35 year old man, was referred from Prince Edward Island, and was admitted to the New England Deaconess Hospital on Dec. 15, 1942, complaining of pain in the right arm and right leg.

History—He had experienced a sudden loss of consciousness in June, 1940, and this had lasted for two to three weeks. A lumbar puncture at the time showed bloody fluid. He made a slow recovery from this episode and had double vision for a period, but was back at his usual work in six months. A second attack of loss of consciousness occurred in June, 1942. At this time the unconsciousness lasted only a few days. A severe headache had preceded this attack. The episode resulted in a complete right hemiplegia and hemihypesthesia. As this weakness and sensory loss cleared up, the patient began to have pain in the right arm and leg which persisted and was the chief reason for his coming to Boston.

Neurologic Examination—There was slight pallor of both optic nerves, but the other cranial nerves were normal. He had considerable weakness of the right face, arm, and leg together with a painful hypesthesia of the whole right side. There was complete astereognosis of the right hand. Deep reflexes were greater throughout on the right, with a positive Babinski sign on this side. The patient was right handed.

It was thought that the patient had an intracranial aneurysm, so a thorotrast injection of the left internal carotid artery was made on Dec. 21, 1942. This showed no aneurysm, but rather what was interpreted as a hemangioma situated deeply in the left hemisphere. However, an oxygen encephalogram on Dec. 22, 1942, showed no ventricular distortion or displacement and was interpreted as normal.

Operation 1—On the same day of the encephalogram a left temporofrontal craniotomy was performed. The left temporal lobe was transected horizontally through the middle convolution down to the temporal horn of the ventricle. Thus exposed a bulging mass medial to the ventricle, and upon incising the ventricular wall over this mass what was taken to be tumor tissue was encountered. An immediate frozen section diagnosis was said to show degenerated tumor tissue, probably of glial origin. The tumor was then removed by the usual combination of suction and electrocoagulation. The growth apparently involved the basal ganglia and the area of the internal capsule. The final pathologic report on the tissue was "degenerated glial tissue with hemorrhage."

Following the operation the patient had an incomplete temporary aphasia, but this had largely cleared up at the time of discharge on Jan 6, 1943, approximately three weeks postoperatively. He likewise had an increase in the right sided hemiparesis and sensory loss, but these likewise improved considerably before discharge.

On Feb 25, 1943, he reported for a checkup. He had been having pain at regular intervals every other day in the right arm and leg, and this required dilaudid for relief. He was given a series of x ray treatments, 1,200 roentgens being used through each temporal region. At the time of this report he had moderate weakness of the right arm and leg, more marked in the arm, together with a marked hypesthesia of the whole right side.

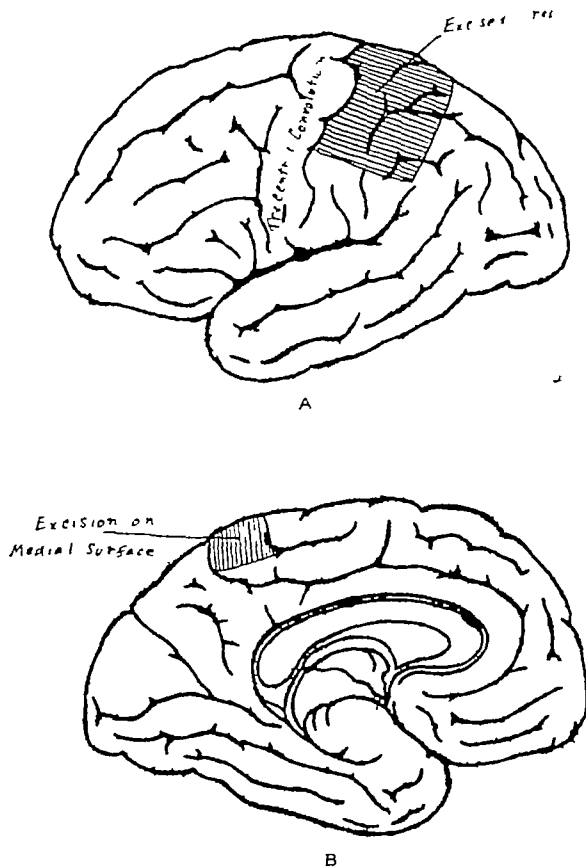


Fig 4—A and B Case 3 F J C

The patient improved and was free of pain for more than one year following the operation and x ray therapy, but on Oct 18, 1944, he reported with a return of pain and was given a second series of roentgen therapy. This failed to relieve him and he was again admitted to the Deaconess Hospital on Nov 4, 1944. The pain was largely in the right hand and arm, but also in the right leg and foot. The pain in the right arm extended from below the elbow down into the hand, and was most marked in the palm. He said it also ran out into the fingers and was "like a knife." As had been the case before, the pain was present only on every alternate day.

Examination showed a right hemiparesis most marked in the right hand and arm. There was likewise a painful hypesthesia of the right hand and arm. He had a right homonymous hemianopsia, but there was no aphasia. The deep reflexes were greater through out on the right with an extensor response to plantar stimulation.

An oxygen encephalogram was carried out on Nov 7, 1944. This showed slight dilatation of the ventricles, somewhat greater on the left side. There was no displacement of the ventricles and no evidence of recurrent tumor.

It was decided to make an attempt to relieve the pain by cortical excision.

Operation 2—Nov 7, 1944, under procaine anesthesia, a craniotomy above the old temporal bone flap was performed and the dura reflected up to the sagittal sinus. By electrical stimulation, areas on the postcentral cortex were disclosed which produced pain in the right arm and leg. These areas were in the convolution just posterior to that from which motor responses had been obtained in the arm and leg. An area of postcentral cortex measuring approximately 3 cm in length, 2 to 3 cm in width, and 2.5 cm in depth was extirpated by a combination of electrocoagulation and sharp dissection (Fig 4, A). The area resected included cortex lying medially along the falx 2 cm in extent (Fig 4, B).

Postoperatively, the patient had considerable increase in the weakness of the right side and was markedly aphasic, but he had no pain in the hand, arm, or leg. At the time of discharge, Dec 4, 1944, his speech had largely recovered and the strength of the right side had improved sufficiently so that he was up and about. He reported for a checkup on Dec 18, 1944, at which time he was improving in all respects and was free of pain.

Jan. 25, 1946, the patient returned, one year and ten weeks following the cortical excision.

He had experienced no pain in the right hand and arm for five months after the operation, but in April, 1945, this pain returned moderately, increasing in severity until November, 1945, when it reached its former intensity, and again occurred on every alternate day. As before, the severe pain ran from the middle of the forearm down into the palm of the hand. *There had been no return of pain whatever in the leg or foot.*

Examination showed some general weakness and spasticity of the right arm and leg, most marked in the arm. All movements of the hand and arm were possible, but hand and finger movements were rather weak, incomplete, and awkward. He walked quite well but with an obviously spastic, hemiparetic gait. There was no trace of aphasia.

There was complete loss of all forms of sensation in the right hand and arm, and the patient had burned himself on the right forearm without his knowledge. Light touch, deep pressure, and pain were all absent. He had some slight hypesthesia to all forms of sensation on the right side of the face, and a very marked loss of all types of sensation over the right foot and leg, but here a pin point was appreciated as pain when fairly firm pressure of the pin was exerted. Arrangements have been made for the patient to re-enter the hospital.

Comment—Although by no means a completely successful result, nevertheless the experience with this patient has been encouraging. He has been free of pain in the right leg for over fourteen months, and had a respite of five months from the pain in the right hand and arm during part of which time he was able to attend to some of his work in an office. It is of considerable interest that the patient himself had been sufficiently encouraged by the operative procedures to return for further possible help. In his own words, "You stopped the pain in my leg and I am sure you can do the same for the arm."

The fourth and final patient, whose history follows, had perhaps the most successful result of all.

Case 4—J. F. J., a man 42 years of age, was referred from Hartford, Conn., and was admitted to the New England Baptist Hospital on Nov 5, 1942, complaining of generalized convulsions for two years. There were no other pertinent features in the history and a complete neurologic examination was negative with normal fundi.

Since a lumbar puncture showed normal pressure, an oxygen encephalogram was carried out on Nov 6, 1942 and the subsequent roentgenograms showed depression of the anterior horn and body of the left lateral ventricle. Three days later a craniotomy was performed

at which time a grossly complete extirpation of a fairly well encapsulated soft glioma was accomplished. The tumor was situated parasagittally in the region of the arm and leg centers and extended downward along the falx. Pathologically it was a fibrillary astrocytoma.

Postoperatively, the patient had a complete hemiplegia for a few days, then gradual return of function starting with the right leg. He was discharged eighteen days after operation.

He was readmitted on April 16, 1944, about one and one half years following the tumor extirpation because he had had an occasional focal seizure starting in the right arm during the past year. In February 1944, he first complained of pain in the right wrist. On April 20, 1944, the old operative site was reexplored but no gross evidence of recurrent tumor was disclosed and a biopsy of some suspicious tissue was microscopically negative. He was discharged on May 3, 1944.

The third admission was on Dec. 18, 1944, at which time the chief complaint was pain of increasing intensity in the right hand and arm, largely from the wrist down. The pain had been increasingly severe since July, 1944, but during the four months previous to this admission it had been entirely incapacitating. The patient showed considerable weakness of the right arm and leg, but was able to get about by himself and walked quite well. There was hypesthesia to all forms of sensation over the right face, hand, arm, and leg.

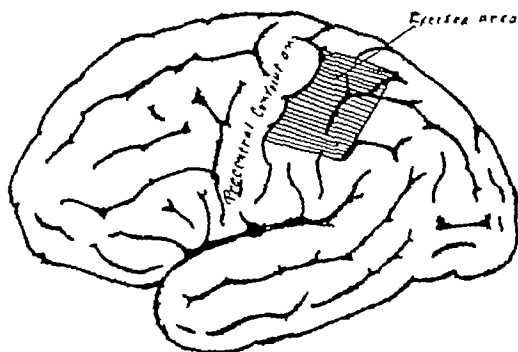


Fig 5—Case 4 J F J

Operation.—Dec. 23, 1944 under procaine anesthesia the old bone flap was turned down and the dura opened widely. There was no evidence of recurrent tumor anywhere.

Electrical stimulation was carried out on what was presumed to be postcentral cortex, and the patient complained of pain in the right arm. At the same time there was some jerking of the right arm followed by a mild convulsive seizure lasting about thirty seconds. By a combination of sharp dissection, together with suction and electrocoagulation, the stimulated area was removed and the excision then continued superiorly to where the patient complained of feeling pain in the right leg. Excision was likewise continued inferiorly to the area from which he complained of feeling pain in the right face (Fig 5). The excision was carried to a depth of 2 cm, and when the cortical removal had been completed, the patient said that all pain in the right hand and arm had been abolished. The tissue removed was reported microscopically as normal cortex without evidence of tumor. The specimen removed measured 4 by 2.4 by 1.2 cm.

Postoperatively there was complete paralysis of the right arm and weakness of the right leg. The strength of the leg was returning when the patient was discharged on Jan. 13, 1945, but the arm was still paralyzed. He had no pain in the hand or arm during the stay in the hospital.

April 23, 1945, the patient reported for a checkup. He had had a slight degree of pain in the right arm, but none in the right hand since operation. He admitted that he had been almost completely relieved of the previous pain. The right arm could be flexed and extended weakly but there was no motion in the hand or wrist. He walked very well.

although with some weakness of the right leg. There was entire loss of pain sensation in the right hand, both palmar and dorsal surfaces, extending dorsally well above the wrist.

July 6, 1945, the patient again reported for a checkup. At this time there was no pain whatever in the right hand and arm but they had become completely paralyzed. He had been having some moderate pain in the right leg and foot during the previous five or six weeks.

Sensory examination showed that light touch was appreciated throughout over the right hand and arm but sharp was felt as dull. There was some lessening of pain sensation over the right foot and leg also. The fundi were normal.

The patient was readmitted to the New England Deaconess Hospital on Nov. 1, 1945. At this time he had been having headaches for about two weeks, together with increasing drowsiness. *He had had no pain in the right hand or arm.*

After admission to the hospital the course was rapidly downhill and he lapsed into coma within forty-eight hours. No further operation seemed advisable. He died on Nov. 5, 1945, and at autopsy a pontine hemorrhage was disclosed. There was a small area, likewise, of recurrent tumor.

Comment—Although this patient was considerably incapacitated by the weakness of the right hand and arm, this disability had been present ever since the tumor extirpation, but was increased following the cortical excision. Due to the previous operations it was difficult to determine either by inspection or electrical stimulation the exact area of postcentral cortex, and for this reason many motor cells were doubtless extirpated. However, the relief from pain in the upper extremity remained complete at the time of death, ten months after the cortical excision.

DISCUSSION

So far as Cases 1 and 2 are concerned there is little to say other than the comments which have been made already in connection with the reports. In view of all the circumstances it is my present feeling that the only procedures which would have been likely to have benefited the patients would have been bilateral prefrontal lobotomies as suggested by Walker⁴ and by White.¹ Both Walker and White quote van Wagenen as having carried out such an operation with success for intractable pain, and similar unreported operations have been performed by an associate* and myself, apparently with equally good results.

In connection with Case 1 there is one further feature of interest. This patient had bilateral cortical excisions of the areas from which electrical stimulation had given him a sensation of pain in the contralateral phantom hand and lower arm, and after brief interludes following each operation, the pain in each phantom hand returned with its previous intensity. No sensory examination of the hands, of course, was possible, and there is merely the patient's statement that pain was present. In so far as it goes, therefore, this experience would cast some doubt on the existence of ipsilateral pathways for pain to the cortex, although it is possible that more extensive excisions might have given a different result.

It is somewhat extraordinary that such a complete loss of pain sensation occurred in the contralateral hand and arm in Cases 3 and 4. From his experience with cortical ablations, Evans⁵ concluded that "Limited excisions of

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cortical substance in the pre- and postcentral gyri and in the central portion of the parietal lobe were followed by transient, if any, sensory dysfunction."

Contrarily, the degree and extent of sensory impairment after cortical excisions has been shown to be extremely variable even when a whole hemisphere has been removed.

The present extent of information in this respect was well summarized by Walker⁴ in a paper read before the Association for Research in Nervous and Mental Disease in December 1942. In this article he gave such findings as were available from the hemispherectomized patients of Dandy, Gardner, and Evans. Walker reported as follows, "It thus must be concluded that extensive cortical lesions may produce varying degrees of hypalgesia from practically no impairment to a severe loss of appreciation of pain."

One further point may be mentioned in connection with the cortical stimulation in the patients here presented. In three out of the four pain was produced in the contralateral hand, arm, or leg when the postcentral cortex was stimulated. This is at variance with the findings of Penfield and Boldrey⁶ in whose experience pain was produced only eleven times out of 800 responses. However, this may have some relation to the strength of electrical current used. The apparatus which I have is not ideal for this purpose and I have felt that the current was frequently too strong inasmuch as it produced mild convulsions in some instances when used on the motor area.

SUMMARY

The results following excision of postcentral cortex for the relief of painful extremities in four patients are presented.

In the two patients with causalgia and phantom limb pain, respectively, the cortical excisions were followed by transient relief only.

In the two patients who had central pain, relief was complete in one during the remainder of his life (ten months). In the other, relief had been complete in the contralateral leg (one year and ten weeks, postoperatively) and was complete in the hand and arm for five months following the excision.

Certain features concerned with sensory responses to cortical stimulation and sensory deficits following postcentral cortical excisions are discussed.

REFERENCES

- 1 White, J. C. Pain After Amputation and Its Treatment, *J. A. M. A.* 124: 1030-1035, 1944.
- 2 Mahoney, C. G. de G. The Treatment of Painful Phantom Limb by Removal of Postcentral Cortex, *J. Neurosurg.* 1: 156-162, 1944.
- 3 Head, H., and Holmes, G. Sensory Disturbances From Cerebral Lesions, *Brain* 34: 102-254, 1911.
- 4 Walker, A. E. Central Representation of Pain, *A. Research Nerv. & Ment. Dis., Proc.* 23: 63-85, 1943.
- 5 Evans, J. P. A Study of the Sensory Defects Resulting From Excision of Cerebral Substance in Humans, *A. Research Nerv. & Ment. Dis., Proc.* 15: 331-370, 1935.
- 6 Penfield, W., and Boldrey, E. Somatic Motor and Sensory Representation in Cerebral Cortex of Man as Studied by Electrical Stimulation, *Brain* 60: 384-443, 1937.

MEGACOLON, MECHANISMS AND CHOICE OF TREATMENT

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MEGACOLON or gigantism of the colon is a relatively uncommon clinical condition. We found in the diagnostic files of the Strong Memorial Hospital thirty-one cases in the last 250,000 admissions, a ratio of approximately 1 to 8,000, which corresponds fairly well with other reported series.¹ The infrequent occurrence of this condition undoubtedly is an important factor in the conflict of ideas concerning both its etiology and its treatment.

In this number of SURGERY celebrating the sixtieth birthday of Dr John J Morton, it seems particularly appropriate to report further studies of megacolon from this clinic. Dr Morton and one of the authors discovered the fact that certain cases of idiopathic dilatation of the colon responded temporarily to spinal anesthesia by evacuation, and proposed the use of such a motor test to determine in advance whether sympathetic denervation of the bowel would be effective. It was anticipated and suggested at that time that not all instances of megacolon would respond in this manner. Experience in this clinic has amply demonstrated such a fundamental difference in the reaction of the enlarged colon in different cases. This fact, together with other clinical features, makes us certain that megacolon is a symptom complex rather than a disease entity, and that at least four different mechanisms of causation can be recognized. As a corollary of this, it is not surprising that treatment along entirely different lines is indicated in the different groups.

CLINICAL GROUPS

Group 1 Organic Obstruction (Congenital)—It has long been recognized that a tremendous dilatation of the colon may be associated with congenital anomalies in the development or fusion of the proctodeum which causes a high-grade but incomplete obstruction of the lower large bowel. Probably this congenital constriction is originally the only defect in the colon, the innervation, musculature, and mucosa being normal. After several years of such obstruction, secondary changes due to dilatation, erosion, and fibrosis may supervene and effect bowel function. Usually, however, it is surprising how such a bowel will retain good emptying power after years of enormous dilatation. A typical example of the group is found in Case 1.

CASE 1 (S M H No 113841)—D W, a 24 year old white woman was admitted to the Rochester Municipal Hospital on May 15, 1936. She had had from birth a congenital anomaly of the rectum. The only outlet of the rectum was through a small fistula opening through the posterior vaginal wall. It was necessary for her to wear a pad all of the time because of incontinence of feces. She had had abdominal distention with crampy abdominal pain or

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the colon has been previously reported in detail and will not be repeated here.² It is impressive to see the huge, dilated, inert colon take on a powerful expulsive function and empty most of its contents within a few minutes, with the appearance of marked haustral markings. And the division of the lumbar sympathetic innervation of the colon has inaugurated regular normal bowel evacuations which were never present before and which have been maintained for seven years in the case of S. until he died of an independent condition.



Fig. 2 (Case 2) —Megacolon in an 11-year-old boy involving the descending colon due to obstruction following operation for an imperforate anus.

In a later report from this clinic, it was announced that certain cases of typical megacolon in children and of obstipation in infants were permanently improved following an effective spinal anesthesia.³ This therapeutic use of spinal anesthesia in such instances has also been successfully used in other

clines.⁴ It would seem that the total number of such cases rules out coincidence as the factor in this correlation.

Diagnosis Most patients with idiopathic megacolon are started on a conservative regime and only those that fail to respond satisfactorily are tested for the underlying mechanism. When the symptoms of megacolon are sufficiently serious, when no mechanical obstruction is found on examination, and when the x-ray findings suggestive of Group 3 are not present, then spinal anesthesia is induced as a motor test. Anesthesia at least to the costal margin has to be achieved for the test to be considered adequate. If, within a few minutes after the induction, the colon vigorously expels most of its contents which the patient was unable to do voluntarily, then the megacolon is considered to be due primarily to neurogenic dysfunction.

Treatment The spinal anesthesia given as a diagnostic test is also used as a therapeutic test in cases of neurogenic dysfunction. A period of at least three months should always be allowed to elapse while conservative measures which had been used previously are continued. If improvement in evacuation has not then shown itself, another spinal anesthetic may be given. Only after at least such an interval, following one or more successful spinal anesthetics, should lumbar sympathetic denervation by operation be considered. This operation as the principal therapy has been deemed advisable in only three patients in our series. Lumbar sympathectomy as an adjunct to resection in Group 3 will be discussed later.

Group 3 Functional Obstruction—Dolichocolon—Satisfactory spinal anesthesia was induced in nine typical cases of idiopathic megacolon. In four of these immediate and extensive evacuation of the distended colon occurred, but in five no effective response was obtained. Sometimes there was no evacuation, sometimes a negligible amount of the liquid barium suspension was expelled. It is this group that concerns us here. Why did this marked difference in the reaction of the two groups occur? Was it because of a fundamental difference in the mechanism producing the megacolon or was the failure of response in the later group due to secondary changes that had supervened? We are convinced by the study of these cases and particularly the patients' response to a mechanically corrective operation alone that the megacolon in most of this group is not of neurogenic origin. The following cases first suggested this conclusion.

CASE 3 (S. M. H. No. 120321)—R. K., an 11 year old boy, was admitted to the Strong Memorial Hospital, Oct. 10, 1936. Since the age of 3 weeks, this boy had had a protuberant distended abdomen and great difficulty in evacuating the bowel. During the first six years, enemas were necessary for any movement of the bowels. Since that time he has had incomplete evacuations that never overcome the abnormal distention of the abdomen. The boy had periods of tremendous distention which lasted from one to three days and interfered with eating and even with normal respirations.

On examination the boy was rather poorly nourished, had a pasty complexion and flabby musculature. Face, arms, and legs were thin but the abdomen was protuberant and markedly distended. No distinct masses could be felt and no peristaltic waves could be seen. Rectal examination was negative. There was no spasm of the sphincter.

Blood counts and urine examination were normal. Wassermann was negative. X-ray examination showed a marked distention of the whole colon from the cecum to a point just proximal to the rectosigmoid. At this point there was a sharp narrowing of the colon and below it the rectosigmoid and rectum were not dilated. This was best shown in the lateral view (Fig 3). After the barium enema he spontaneously was able to evacuate two quarts or more of liquid. Even after this, however, there was a marked dilatation of the colon with extreme redundancy of the sigmoid. Spinal anesthesia to the nipple line produced no further emptying of the colon.

Due to the point of constriction with the sudden change from marked dilatation above to a normal diameter below, it was felt at first that there might be some cause of organic obstruction at this point such as a band or a congenital fault in development.



Fig 3 (Case 3) —Megacolon in an 11-year-old boy. Lateral view shows the sharp smooth conical transition from the greatly dilated sigmoid to the normal rectum and rectosigmoid. The constriction in dolichocolon regularly occurs at approximately this point, namely just proximal to the point of fixation at the rectosigmoid.

Operation was carried out Dec 14, 1936. The whole descending colon was enormously dilated to the point shown in the x-ray picture where there was a conical transition to a normal appearing rectosigmoid. The wall of the distended colon was thickened, and the sigmoid loop was greatly elongated and filled with semiliquid contents. At the point of transition there was no structure that could be seen that would cause a constriction. And on lifting the distended sigmoid loop it was seen that the weight of its contents had caused a sharp kinking of the lower sigmoid at this point. Gas and fluid could easily be made to pass through the cone when the sigmoid loop was lifted up, straightening out this kink. A large rectal tube was easily passed up from the outside through the rectum and past the point of transition, showing that the blockage at this point was functional rather than anatomic.

The dilatation of the colon extended into the left half of the transverse colon, gradually diminishing in extent. The ascending colon and right half of the transverse colon were not much distended and showed good haustral markings. In order to prevent this functional kinking of the lower sigmoid, the splenic flexure was mobilized and the colon from just to the left of the mid transverse colon to the lower part of the sigmoid was delivered into the wound and resected by the Mikulicz procedure. The great mass of dilated colon was removed immediately and the spur was crushed before discharge. The patient began to gain weight at once with marked improvement in general condition. It was necessary to do a plastic closure of the colostomy opening. He then had regular bowel movements for five years, grew normally, and, except for an occasional minor upset associated with impaction of inspissated fecal material in the rectum, he was without symptoms. The later course will be presented in the section on complications.

In this case, spinal anesthesia was ineffective and we found that the fundamental mechanism in the production of the megacolon was a functional obstruction apparently due to an abnormal increase in the length of the sigmoid, namely, dolichocolon. When this abnormally long loop is filled, it causes a kinking just proximal to its fixed point, namely, just above the rectosigmoid. Five other patients have been operated upon in this same manner by resection of a very redundant loop which was thought to be causing a functional obstruction, the location of which was always in this same region.

CASE 4 (S M H No 199255)—P L, a 4½ year old boy, was admitted to the Strong Memorial Hospital, Dec. 5, 1942. He had been severely constipated all his life, going several days without bowel movements and requiring cathartics and enemas. When the bowels moved there were very hard masses followed later by liquid stool. The abdomen had become very prominent and protuberant, especially on the left side.

On physical examination the boy was fairly well developed but rather thin and with a pasty complexion. In the erect position, he had a diffuse protuberance of the abdomen and on lying down there was a visible mass extending from the left upper quadrant to just above the symphysis. This mass was doughy, nontender, and freely movable. It undoubtedly represented a distended sigmoid. Rectal examination was negative, the sphincter was not spastic.

Blood and urine studies were normal. Stool was negative to guaiac.

Barium enema (Fig 4) showed marked redundancy and dilatation of the whole descending colon but not extending to the transverse colon.

The patient was put on a conservative regimen without improvement in symptoms, bowel habits, or x-ray appearance (Fig 5), consequently, he was operated upon on April 23, 1943. There was an enormous redundant loop of a sigmoid with a point of functional obstruction just proximal to the rectosigmoid. When the very heavy loop of sigmoid was lifted up (thus straightening out the kink), gas passed readily into the collapsed rectum. A rectal tube was passed from the outside through the rectum into the dilated sigmoid without meeting any obstruction. The transverse and ascending colon appeared normal, and the distention gradually tapered out in the upper part of the descending colon. Most of the descending colon was now removed. The removed segment had a diameter of 8 cm. The ends were closed and a side-to-side open anastomosis was carried out between the proximal and distal segments.

He was discharged from the hospital on the thirteenth day, already having daily bowel movements. An x-ray (Fig 6) taken three weeks after operation shows the correction achieved. He has continued to have regular bowel movements and the prominence of the abdomen has disappeared.

CASE 5 (S M H No 204142)—M P, a 3½ year old girl, was admitted to the hospital on April 26, 1943. Since birth she had never had spontaneous bowel movements, cathartics



Fig 4



Fig 5

Fig 4 (Case 4) —Dolichocolon in a 4-year-old boy, showing dilatation of the whole descending colon and redundancy of the sigmoid. The point of transition does not show well in the anteroposterior view. Appearance of the colon on admission.

Fig 5 (Case 4) —No striking improvement after four months of conservative treatment. The redundant sigmoid loop is more transverse here than as shown in Fig 4.



Fig 6 (Case 4) —Postoperative appearance after resection of redundant sigmoid. The projection toward the midline opposite the side-to-side anastomosis is the distal end of the proximal sigmoid which was a little longer than necessary.



Fig 7



Fig 8

Fig 7 (Case 5) —Dolichocolon in a 3½-year-old girl showing dilatation of the whole descending colon

Fig 8 (Case 5) —Lateral view showing marked redundancy of the sigmoid



Fig 9 (Case 5) —Barium enema on eleventh postoperative day showing complete correction of both dilatation and redundancy

and enemas being necessary every second day for any evacuation. At the age of 18 months, she had a fecal impaction which had to be removed manually.

On examination, the only significant findings were marked prominence of the abdomen, especially on the left, with a tubular, soft, movable mass undoubtedly distended sigmoid.

Blood and urine studies were normal except for a slight anemia. Stool was guaiac negative. Barium enema showed dilatation of the entire descending colon (Fig 7) and on lateral view the marked redundancy of the sigmoid (Fig 8).

After a short course of conservative treatment without improvement, she was operated upon on May 10, 1943. A tremendously redundant and enlarged loop of sigmoid was found filling the pelvis and lower abdomen. This loop was lifted up and the transition between the greatly enlarged sigmoid and the normal distal bowel was a sharp conical segment not over two inches in length just proximal to the rectosigmoid. The redundant sigmoid was resected and the descending colon anastomosed to the rectosigmoid with a side to side anastomosis after closing the ends.

The patient began having regular daily bowel movements on the seventh postoperative day and has continued with good bowel habits. Barium enema on the eleventh postoperative day showed complete correction of both dilatation and redundancy (Fig 9). She was discharged on the thirteenth postoperative day.



Fig 10 (Case 6) —Dolichocolon in a 5-year-old girl showing marked redundancy with some dilatation and absence of haustration in the sigmoid.

Combined operation—resection and sympathectomy In two children, where the barium enema suggested such a dolichocolon, resection of the redundant loop has been combined with a left lumbar sympathetic ganglionectomy without any preliminary spinal anesthetic motor test. In one case the result was brilliant while in the other one there was a recurrence of difficulty in bowel evacuation after five months of complete relief.

CASE 6 (S M H No 229167) —T N, a 5 year old girl, was admitted to the Strong Memorial Hospital, March 8, 1945 She had been markedly constipated since birth and as many as two weeks passed without bowel movements, which were achieved only after adult doses of cathartic. Stools when they occurred were abundant, foul smelling, often grayish white in color, and occasionally bloodstreaked She had lower abdominal crampy pain, rather marked distention, and one episode of vomiting Breath had been quite foul

On examination there was a doughy mass in the left lower quadrant which was probably a distended sigmoid loop Rectal examination was negative On barium enema there was a marked redundancy and dilatation of the sigmoid colon without haustral marking (Fig 10)

After a short course of conservative treatment, including mecholyl, had failed to improve the bowel function, operation was resorted to Spinal anesthesia was not tried as it was obvious that the marked redundancy of the sigmoid would continue to be a menace even though evacuation could be achieved by sympathetic denervation Instead, a left lumbar sympathetic ganglionectomy (from the second to the fourth lumbar segment inclusive) was first carried out and then the greatly elongated and dilated sigmoid loop which extended from the pelvis up to the liver and back was resected, the ends were closed, and a side to side anastomosis was carried out between the anterior surface of the rectosigmoid and the ante mesenteric surface of the upper descending colon (between the haustral bands) When the opening in the mesocolon was closed, the reconstructed descending colon lay in the left iliac fossa without redundancy Less than two weeks after operation the patient began having regular spontaneous daily bowel movements which have continued to date And, one year later, she had gained weight and grown well, had lost the foul breath, fullness of the abdomen, and abdominal pain

In this case, left lumbar sympathectomy was combined with resection of the redundant colon Possibly this was unnecessary, but we felt that it could easily be done at the same time without adding materially to the risk of operation And, we preferred to carry out the combined procedure rather than to test the bowel function with spinal anesthesia The absence of haustration suggested that there might be an element of sympathetic inhibition and we were certain that the marked redundancy of the colon was an indication for resection The recurrence of symptoms in the second case after five months of complete relief is unexplained This is the most recent case and this patient may require a more extensive resection of the colon

Spinal anesthesia as an adjunct in the treatment of acute dilatation in dolichocolon We have stated that spinal anesthesia is not effective in evacuating the bowel in cases of dolichocolon However, we found its use as a therapeutic adjunct of benefit when the colon becomes dangerously distended with gas and fluid The following case illustrates this use

CASE 7 (S M H. No 206231) —G T, a 4 year old boy, was admitted to the hospital, July 6, 1943 He had been severely constipated since birth, requiring enemas and cathartics daily for bowel movements At the age of 2 this became worse and even with larger doses of cathartics and enemas, four or five days passed without bowel movements He had marked distention of the abdomen occasionally accompanied by nausea and bouts of vomiting

On examination, he had marked general abdominal distention, otherwise there was nothing remarkable. On rectal examination, the rectum was filled with hard fecal material, the sphincter was of normal tonus Barium showed marked dilatation and redundancy

At first, he responded favorably to mecholyl and enemas but in a few days he developed an extreme distention of the abdomen, the skin being stretched tightly over the tremendously enlarged colon (Fig 11) which even somewhat embarrassed respirations In this condition,

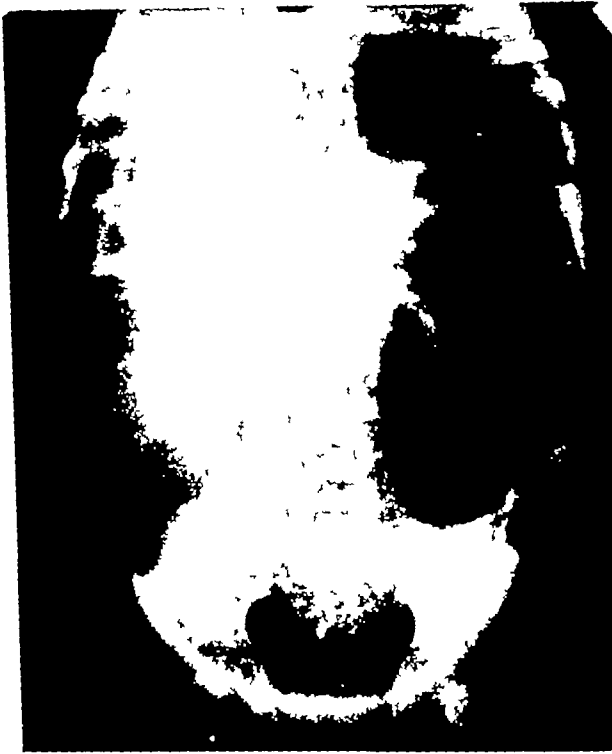


Fig. 11 (Case 7) —Enormous distention of the colon before spinal anesthesia in a 4-year old boy with dolichocolon



Fig 12



Fig 13

Fig 12 (Case 7) —Improvement in the dilatation of the descending colon with conservative treatment (two months after view shown in Fig 11)

Fig 13 (Case 7) —Dilatation controlled by conservative regime including mecholyl but redundancy remains as much a menace

spinal anesthesia was induced. It was not followed by the typical rapid expulsion seen in cases of neurogenic dysfunction. After complete relaxation of the abdomen, however, with manipulation and clockwise pressure on the dilated colon, some gas was finally expressed and with further efforts quantities of gas and liquid fecal material were moved into the rectum and evacuated through a large rectal tube.

After this decompression of the acute dilatation, he responded well to mechlolyl, mineral oil, and enemas and was discharged on this conservative regime. Barium enema two months later showed the extent of improvement in the dilatation (Fig 12). Upon the discontinuance of mechlolyl, the symptoms again became aggravated and the sigmoid dilated, but redundancy has persisted even when the symptoms have been under control (Fig 13). Resection of the sigmoid should probably be done to prevent recurrent episodes of dilatation.

The spinal anesthesia in this case seemed to be of definite help in overcoming the episode of acute dilatation. It probably acted partly by paralyzing the tense abdominal musculature, partly too, possibly, in setting up vigorous peristaltic waves. Without the mechanical measures to move the gas and fluid past the functional obstruction near the rectosigmoid, it was ineffective, but as an adjunct to such it was of real value. Spinal anesthesia must not be used, of course, where there is any doubt about the viability of the bowel. There is probably some danger inherent in its use with such an extreme dilatation of the colon. This later danger, however, was not as serious as the danger from allowing this condition to persist.

Late complications of dolichocolon. In Case 3 (outlined previously), in the later course, an important factor was shown in the operative management of dolichocolon. Six years after the resection of the colon by the Mikulicz method, the patient developed a partial obstruction at the site of the resection with marked dilatation of the colon above this point (Fig 14). An anastomosis around the point of constriction was carried out, which was proved by x-ray to be widely patent (Fig 15). In spite of this fact, however, the dilated colon did not empty itself satisfactorily. A colectomy was done removing all of the colon to the rectosigmoid. A T-shaped anastomosis between the terminal ileum and the rectosigmoid was first tried with the idea of providing a storage reservoir in the terminal segment of the ileum. This proved unsatisfactory, but after changing the anastomosis to a wide side-to-side opening, the obstructive element was entirely overcome (Fig 16) and the evacuations became excellent. At first the stools were entirely liquid, but within a few months they became less so and now, over one year after operation, they are soft solid.

This case is the only one in our series that has required removal of the right half of the colon. We are of the opinion that such is unnecessarily radical in all but a few cases but we do agree with Gimson, Vandegrift, and Dietz that there are some cases that will require it.

This experience has also influenced us to use a wide side-to-side anastomosis usually in resection of the colon for dolichocolon. We have, of course, abandoned the Mikulicz type of resection, but we are under the impression that there is less likelihood of a late constriction at the site of the anastomosis with a side-to-side opening than with an end-to-end union in dolichocolon. We are confident that in dolichocolon even a slight constriction may be detrimental to the function of



Fig 14



Fig 15

Fig 14 (Case 3) —Partial obstruction at the site of Mikulicz resection with marked dilatation above it.

Fig 15 (Case 3) —Dilatation of the descending colon persists even after widely patent anastomosis and treatment with mechoyl



Fig 16 (Case 3) —Final operative result in Case 3 after total colectomy showing complete elimination of the obstructive element and direct filling of small intestine from the rectum with barium enema.

the colon above this point. For this reason we have placed the opening between the taeniae in the proximal segment as there is probably less connective tissue formation.

Group 4 Extrinsic Metabolic Effects—There apparently are other factors contributing to the formation of megacolon which are difficult to assess. Because we do not know the specific mechanisms and the behavior of these extrinsic factors in the causation of megacolon, we feel justified in mentioning that these cases occur and should be included in any comprehensive survey.

In our group we have had a few cases which are definitely related to metabolic disturbances, as avitaminosis, malnutrition, thyroid deficiency. Correcting the specific deficiency factors seemed to improve both the clinical behavior and x-ray appearance of the large bowel. Whether or not these cases can be considered as definite clinical entities, one cannot state at this time, but any case of megacolon should be investigated for such possible contributing factors.

SUMMARY OF MANAGEMENT FOR MEGACOLON

When a patient appears for treatment with symptoms of megacolon, namely, long-standing obstipation, abdominal distention, etc., and with the x-ray evidence of a greatly dilated colon, we have arrived at the following plan of combined diagnostic classification and clinical management:

- 1 Organic obstruction of congenital origin is first excluded by examination.
- 2 Factors depressing the metabolic effectiveness of the smooth muscle of the colon (Group 4) are searched for and treated if found.
- 3 These two causes of disturbance in the emptying of the colon account for only a small minority of the cases. The remainder are then classified as idiopathic megacolon and the patients are put on a medical regime consisting of repeated colonic irrigation, mineral oil and occasional very mild cathartics, vitamin supplements, low-roughage diet, and parasympathomimetic drugs. This regimen usually produces some improvement in symptoms which may be sufficient to warrant its continuation as the only form of therapy.
- 4 If conservative treatment fails to relieve symptoms after a thorough trial, then one of two courses is chosen: (a) the employment of spinal anesthetic motor test where the x-ray evidence is not strongly suggestive of dolichocolon, or (b) immediate exploration and resection of the colon where the x-ray evidence of a functional obstruction from redundancy (dolichocolon) is convincing.
- 5 When satisfactory spinal anesthesia is ineffective then the case is classified as dolichocolon and resection carried out as under (b), even though the evidence from the routine barium enema may not be sufficiently clear cut to make the differentiation between the neurogenic and dolichocolon types.
- 6 When spinal anesthesia is effective then the previous conservative regime is continued for at least three more months and may be repeated if gradual improvement in symptoms does not appear.
- 7 Sympathectomy is advised only for the small number of patients who respond dramatically to spinal anesthesia but fail to have relief of symptoms after one or more such induction.

8 Recently our experience has led us to advise early operation in certain young children. When a marked obstipation has been present from birth and the barium enema shows an extreme redundancy of the colon with kinking just proximal to the rectosigmoid, we have found that conservative measures and parasympathomimetic drugs are usually ineffective. Consequently, after the failure of a short course of medical management in such cases we have resorted to early operation. In such instances when, in addition to the previously mentioned findings, the haustral markings are absent in the left colon, resection of the redundant colon has been combined with left lumbar sympathectomy without a spinal anesthetic motor test being carried out. Whether this combination offers more than resection alone is not yet proved.

9 In any case, when resection of the colon is carried out for dolichocolon the surgeon must use the utmost care to prevent the subsequent development of any obstructive element. We believe that a long side-to-side anastomosis placed between the taeniae is the preferable type of reconstruction under the circumstances (although we ordinarily choose an end-to-end anastomosis, usually of the aseptic type, for most resections of the colon).

CONCLUSIONS

1 Megacolon is caused by at least four fundamentally different mechanisms

- (a) Organic obstruction of congenital origin
- (b) Neurogenic dysfunction
- (c) Functional obstruction from extreme redundancy (dolichocolon)
- (d) Metabolic factors extrinsic to the colon (hypothyroidism, avitaminosis, malnutrition, etc.)

2 By a careful study the cases can usually be differentiated into clinical groups dependent upon the mechanism of production.

3 Treatment should differ depending upon the clinical group of the case. A plan of management for all cases of megacolon is outlined, based on such clinical differentiation.

REFERENCES

- 1 De Takats, G., and Biggs, A. D. Congenital Megacolon, *J. Pediat.* 13: 819, 1938.
- 2 Scott, W. J. Merle, and Morton, John J. Sympathetic Inhibition of the Large Intestine in Hirschsprung's Disease, *I Clin. Investigation* 9: 247, 1930.
- 3 Stabins, S. J., and Morton, John J., and Scott, W. J. Merle. Spinal Anesthesia in the Treatment of Megacolon and Obstinate Constipation, *Am. J. Surg.* 27: 107, 1935.
- 4 (a) Telford, E. D., and Simmons, H. T. Treatment of Gastrointestinal Achalasia by Spinal Anesthesia, *Brit. M. J.* 2: 1224, 1939.
- (b) Also several personal communications.
- 5 Grimson, K. S., Vandegrift, H. N., and Dratz, H. M. Management and Prognosis of Megacolon (Hirschsprung's Disease), *Am. J. Dis. Child.* 68: 102, 1944.

ARTHRODESIS OF SUBTALUS AND MIDTARSAL JOINTS OF THE FOOT

HISTORICAL REVIEW, PREOPERATIVE DETERMINATIONS, AND OPERATIVE PROCEDURE

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INTRODUCTION

DEFORMITY with or without instability of the foot resulting from trauma, infection, disordered nerve impulses, or congenital influences usually produces impairment in the function of locomotion. Correction of or compensation for these defects to improve function has been attempted by conservative measures such as manipulation and mechanical appliances, also by surgical procedures, including operations on the various tendons, bones, and joints of the foot.

Historical Review—Many of the gross limitations of conservative treatment have been overcome by operative procedures. Since 1879 the relationship of the talocalcaneal, talonavicular, and calcaneocuboid joints to deformity and instability of the foot has been emphasized. The principles which govern successful arthrodesis of these joints have gradually been developed, and the procedure is recognized as most effective in correcting deformities of the feet, and improvement in function of locomotion.

Indications—This arthrodesis is indicated whenever deformity with or without instability of the foot is accompanied by a laterally stable astragalus. The operation is seldom advisable in patients under the age of 7 years. In all instances, the local and general conditions of the patient should favor osteogenesis required for arthrodesis.

Reduction of Surgical Difficulties—Certain technical difficulties have been experienced and reported. It is believed that these can be diminished, if not entirely eliminated by the application of principles defined in this paper.

There is no operation so frequently done on the foot which involves as many articular surfaces at one time. This fact makes prerequisite an intimate knowledge of the normal structure and function of the bones and joints involved.

Preoperative Analysis—There are relatively wide differences in the characteristics of these articulations in "normal" feet. These differences are much greater when deformities prevail. Preoperative analysis of each deformed foot has better defined the particular requirements and led to the most effective end results.

Exposure—These preoperative determinations having been made, the greatest assurance of avoiding minor difficulties and major complications is to be

found in that single incision through which clear exposure is given simultaneously to all of the articulations involved. For this reason a lateral exposure, modified Czianz, which fulfills these requirements is described with illustrations.

HISTORICAL REVIEW

1870-1890—A review of the literature reveals that our present concept of the relationship of this operation to the correction of deformities and improvement in stability of the foot has been developing since Albert,² of Vienna, and Von Lesser,³ of Leipzig, executed the first arthrodesis on the foot in 1879. In 1884, Samter,²⁸ of Königsberg, arthrodesed both the ankle and subastragalar joints. About the same time, Karewski⁶ did an arthrodesis on both the ankle and the midtarsal, astragaloscaphoid joint, as did Ogston,¹ Gluck,⁷ Zinsmeister,⁵ Broca,⁴ and Stokes,²⁹ 1884-1886. The astragaloscaphoid arthrodesis was developed by Ogston,¹ in 1884 and the cuneiform resection of the head of the astragalus was first reported by Stokes,²⁹ in 1885.

1890-1900—Kirmisson⁸ fused the ankle joint by "decortication" and the subastragalar joint by "excarnation." About this time (1890), there was developed a tendency to do arthrodesis on the joints of the foot without producing fusion of the ankle. Then Kirmisson⁸ combined the cuneiform resection of the head of the astragalus with excarnation or resection of the scaphoid.

1900-1905—In 1901 Whitman⁹ ^{10, 32} described an "operation for paralytic talipes of the calcaneus type," requirements (1) removal of the astragalus, (2) "backward" displacement of the foot "so that the internal malleolus is brought into contact with the scaphoid." Further observations were reported in 1901, 1902, 1910, 1921, and 1922.

Subsequently, Dunn²⁵ ³³ joined Sever²⁶ and Jones and Lovett^{27, 52} in opposing the Whitman astragalectomy for paralytic feet, except for selected cases. Satta³ stated that "it has not a single rational indication." Steindler,¹³ in 1925, reported that postoperative results on 105 cases, one or more years after operation, were 83 per cent good, 15 per cent fair, 15 per cent poor.

Hoke³⁰ stated, "Astragalectomy, except for the calcaneus type of deformity for which Whitman devised it, and possibly for flail-feet, is certainly an objectionable operation."

Ombrédanne³¹ stated that, "Elle comporte en premier lieu une astragalectomie, ce qui n'est point original, c'est en 1883 qu'Eugène Boeckel (de Strasbourg) présentait pour la première fois à la Société de Chirurgie une communication sur le traitement des pieds bots invétérés par l'extirpation de l'astragale." He definitely reserved the operation for selected cases.

Davis²³ stated, "The removal of the astragalus weakens very much the foot, in itself is quite a deforming procedure and its loss materially shortens the total length of an extremity which is already disproportionately short when compared with the opposite side."

Reyerson³⁶ stated, "Astragalectomy was designed for the relief of calcaneus and calcaneo-valgus deformities, and has unquestionably been the most successful in use at the present time in the treatment of this particular deformity."

Many operators, however, have used it in cases of equino-varus, and the results have been almost uniformly unsatisfactory "

1905-1910 — Arthrodesis of the ankle joint was advocated by Townsend,¹⁴ in 1905, and by Goldthwait,¹⁸ in 1908. In 1908 also, Jones¹⁹ described an operation for the stabilization of flail foot resulting from complete paralysis. He advised operation at two stages with an interval of two weeks.

1910-1915 — In 1911 Ombriédanne³¹ conceived the use of a curved incision, with convexity downward, beginning behind the external malleolus and passing onto the dorsum of the foot in the direction of the midtarsal joint. No illustration is presented to define more clearly the course of the incision, but it is stated that arthrodesis was done on both the subastragalar and midtarsal joints through this exposure.

Soule,²² in 1912, without reference to any of the foregoing work, made the following statements: "It will be found, on careful examination, in many cases of either varus or valgus deformities arising from infantile paralysis, that the deformity does not include the astragalus. This bone remains, in many instances, secure in its normal position, unchanged in its relation to the tibia and fibula, the varus and valgus occurring at the astragalo-scaphoid, calcaneo-astragalar, or at both of these articulations.

"With the astragalus thus furnishing a secure anchorage, it is a comparatively easy matter to rectify the varus or valgus deformity by first overcoming any resistance to over-correction of the foot and then performing an arthrodesis of the astragalo-scaphoid, calcaneo-cuboid, or both of these articulations, thus furnishing a secure restoration of the foot without appreciable loss of function, as we have the normal astragalo-tibial articulation remaining, permitting full flexion and extension of the foot."

In 1911, Lorthioir²¹ described a method of arthrodesis of the foot "with temporary extirpation of the astragalus." The procedure calls for the removal of the astragalus. The cartilage is then completely removed from the head, also from the superior and inferior surfaces of the body. This had the advantage of producing a minimum shortening as compared with complete astragalectomy. The disadvantages were loss or limitation of function in the ankle joint and the minimum correction of deformity at the calcaneocuboid joint.

The Davis²³ operation, reported in 1913, is probably most generally accepted as the first fundamental concept directed at arthrodesis of the subastragalar joints. Davis' description of the procedure is given in the following quotation (There were no illustrations in the original article):

"For reasons detailed above, and especially with the object of avoiding the removal of the astragalus, it was thought that the object desired might be accomplished by making a transverse horizontal section of the foot below the malleoli and then pushing the foot back and the leg forward. For this purpose the following operation of transverse section was done. The incision is made on the outer side of the foot about two inches long, extending from the posterior edge of the external malleolus forward, it lies close to the tip."

1915-1920 — Dunn,^{25 33 42} in 1919, first reported his operation for calcaneo-cavus. In 1922 he presented an excellent outline of treatment of paralytic de-

formities of the foot, revealing the limitations of conservative measures, tendon operations, and astragalectomy

"The human foot is adapted for support and locomotion. The most important movement in propulsion of the body is controlled flexion and extension at the ankle. We should, therefore, retain this movement at the ankle if possible. We can do this by sacrificing the mid-tarsal and subastragaloid joints. Bony union of these ensures stability of the foot, leaving much muscle power as is present for control of the ankle movements. We cannot restore power to the atrophied muscles, our efforts must therefore, be directed to diminishing their task. We can do this by reducing the number of joints which they control. Our consideration of this point will be most effective if we also recognize the relative importance of the various movements of the foot."

Although pleased with the result of Hoke's work, Dunn stated, "The procedure described by Hoke is, I am sure, unnecessarily complicated. He would appear to emphasize the importance of the direction of the neck of the astragalus in its relation to the foot rather than the relation of the foot to the neck of the astragalus."

1920-1925 — Among the most fundamental contributions on this subject is the paper presented by Hoke³⁰ in 1921. His work began in 1917, and the operation is described as follows: "The skin incision extends from over the external portion of the head of the astragalus downward and backward to the peroneal tendons, below the end of the fibula. The incision and exposure shown in the illustrations are different from the incision and exposure made at the operation. To show bone details, the artist had to disregard other things." Reliance is placed upon postoperative manipulation, after five weeks in plaster, for the correction of any "downward pitching of the metatarsals."

Ombiédanne,³¹ in 1921, mentioned Boeckel's single incision used by Dueroquet-Launay and Broca. It began in front of the external malleolus and passed forward toward the fourth metatarsal. No other reference to this incision has been found.

In July, 1923, Reyerson³² published an excellent paper on "Arthrodeseing Operations on the Feet." The physiologic characteristics were clearly presented, their relationship to deformities of the foot emphasized, and the rationale of arthrodeseing operations for correction of deformities was well defined. The following expression of his point of view is quoted:

"The triple arthrodeseis is indicated where most of the weakness and deformity occur in the subastragaloid and medio-tarsal joints. Mid-tarsal valgus and varus and severe hollow claw-foot are good examples. The operation is most easily and accurately performed by two incisions, one on the inner and one on the outer side of the foot."

In 1923, Steindler³³ recommended "pan-astragaloid arthrodeseis," a modification of Goldthwait's¹⁸ and Lorthion's²¹ operations. Since this procedure includes arthrodeseis of the ankle articulation, its usefulness is limited by the fact that it is less frequently indicated.

The following conclusions are quoted from a paper by Brown,³⁴ 1924, on "The End Results of Stabilizing Operations on the Foot."

"Greater care should be taken at the time of the operation to insure the foot being put into the best mechanical alignment possible. It should be possible to get the os calcis into a straight position if the operation is done properly. It may not and very often will not be possible to get the forefoot in the proper relation to the posterior foot at the first operation, but it is the duty of the surgeon to see that this relationship is established before the patient is discharged from his care. This should be possible to accomplish by manipulation or corrective plasters if it is done within six to eight weeks after the first operation and it should always be done.

"As orthopaedic surgeons we should not be satisfied with pleasing the patients by making them better than they were before. We should be satisfied only by doing an operation and following-up the after-treatment in such a way that the patient gets a result that is mechanically as perfect as possible. In this kind of work anything less than this means that we have not lived up to the standards which we should always have before us."

Craigm³⁹ described "The Arthrodesis of the Foot by Means of Astragalectomy Followed by the Partial or Total Remplantation of the Astragalus." The incision used, "began from the middle of the neck of the foot, a little in front of the rise formed by the head of the astragalus, descends obliquely below and behind, towards the external border of the foot passing over the great apophysis of the heel a little behind the calcaneo-cuboid articulation, is reflected behind to pass under the external malleolus and ascends again along the posterior margin of the said malleolus on crossing over the peroneal tendons up to its base."

1925-1929 —In June, 1925, Smith and Von Lackum⁴⁰ published a study in end results on subastragal arthrodesis. "Two incisions are usually used, one over the inner side of the foot just below and in front of the medial malleolus and extending downward and forward across the astragalo-scaphoid joint and the other reaching forward from the tip of the lateral malleolus across the calcaneocuboid joint."

They stated the following conclusions

1 "Subastragaloid arthrodesis is an operation of great usefulness and wide applicability for stabilization of the foot if correctly done, but it is one of the most difficult operations to perform and demands from the surgeon much skill and experience as well as meticulous after-care

2 "It is of prime importance to displace the foot backward beneath the astragalus as well as to get it in a neutral lateral position

3 "The astragalus is stable in the majority of cases. In the few in which it is not, subastragal arthrodesis can still be done successfully provided the foot is well plated laterally and antero-posteriorly

4 "The operation is adapted to nearly every type of foot deformity. In this series the best results were in calcaneal feet

5 "The operation may be performed as early as the sixth or seventh year

6 "The poor results are due in every case to failure to obtain good position of the foot at operation, to removal of plaster support too soon after operation to failure to obtain fusion, or to disregard the torsion of the tibia. These errors were the result of our ignorance of the function and mechanics of the foot

7 "The optimum result can be obtained in practically all cases provided these conditions are fulfilled "

In February 1929, MacAusland⁴³ described a procedure which was not a significant departure from previous practice

1930-1940 —In 1930 Cole⁵⁰ stated, "The type of incision used in these cases seems to be of no great importance, and to largely be a matter of personal preference, There is an external incision in a valgus deformity, but few operators put any stress on this point



Fig 1 —Relationship of target, foot, and x-ray film in making mediolateral view

"Any failures in these operations are due to (1) improper or insufficient operation, including failure to obtain correct posterior dislocation, (2) failure to balance the remaining muscle power, and (3) failure to remove sufficient wedges to completely overcome the existing deformity or deformities

"Subastragalar arthiodesis, either alone or combined with tendon transplantation or bone block, is indicated in a greater number of cases than any other one operation in the treatment of paralytic feet

"The form of the operation need not be stereotyped if the underlying principles of bony stabilization as first emphasized by Davis are kept in mind

"The desired result should be obtained in practically every case with the proper selection of operation and careful technique "

As related to operative procedure, that is, arthrodesis involving all three joints including the sustentaculum tali, there was no significant departure from views expressed prior to this ten-year period



Fig 2 —Relationship of target feet, and film in making plantar dorsal view

In 1936, Oscar Miller¹¹⁴ advocated this procedure in the surgical treatment of pes calcaneus. He emphasized the need for "(1) accurate evaluation of the bony and muscular pathology, (2) the correction of overgrowth and disturbed relations in the depth of the os calcis and astragalus by a calcaneus type of stabilization, (3) the dressing of the foot in an over-corrected position after operation and after manipulation, (4) the best possible balancing of muscle pull where tendon transplantation is indicated, and (5) careful direction of early weight-bearing in properly built shoes "

PREOPERATIVE ANALYSIS

This operation, as described in the literature, could be most beneficial to the greatest number of patients, provided there was uniformity in all deformed feet

There has been found no method for determining, before operation, the particular characteristics of a deformed foot

The following preoperative analysis was developed for the purpose of accurately revealing the individual variations. By so doing, the operation may be directed toward correction of the particular structural abnormalities at respective levels



Fig 3—Preoperative roentgenogram of hall foot.

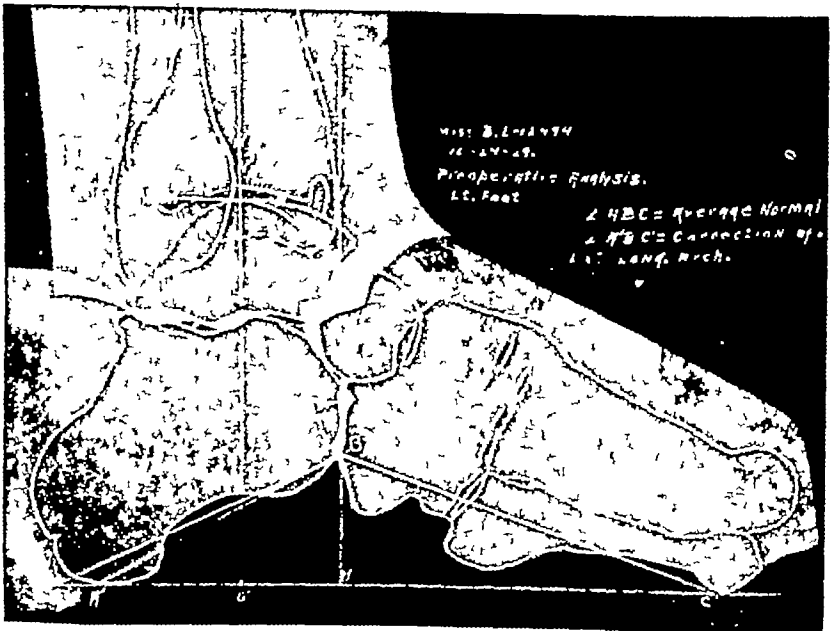


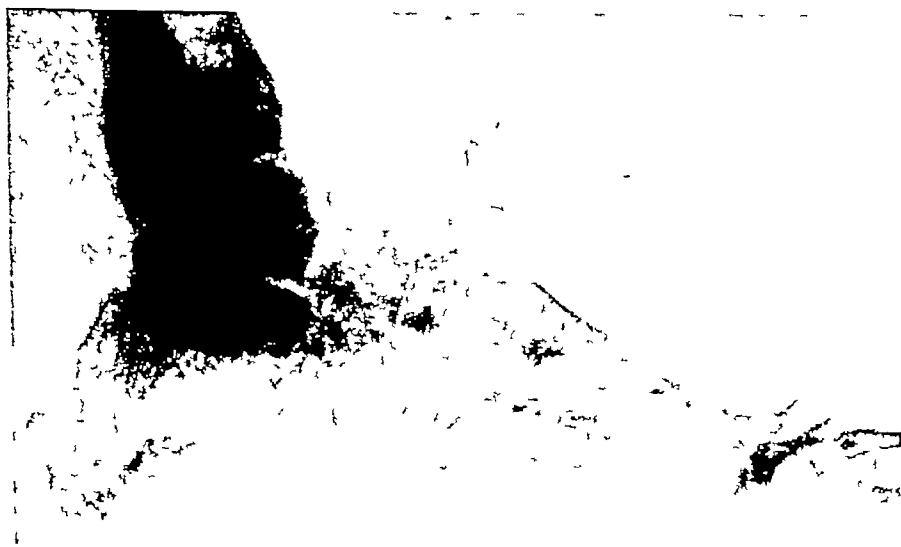
Fig 4—Preoperative analysis

Application of the method provides a preoperative concept of the best relationship which can prevail between the four respective bones of the particular foot under consideration

This concept is expressed in the reconstructed tracing of the preoperative lateral view of the deformed foot. By superimposing this tracing over the post-



A



B

Fig 5—A Postoperative roentgenogram tracing of preoperative analysis superimposed B Postoperative roentgenogram immediately after operation

operative result there is established a comparison of the most effective restoration as planned and the end result attained in the particular foot

Description of Method—Mediolateral and plantar dorsal x-ray negatives are made as illustrated in Figs 1 and 2

An accurate tracing is made of the mediolateral view (Fig 3) It is cut in three parts and arranged on base line as in Fig 4, the average elevation of



Fig 6—The smooth curve of the one incision of the lateral surface of the foot passes over the articulations of the os calcis and ends over the middle of the dorsal surface of the scaphoid



Fig 7—After preparation of the skin. Foot and leg are covered with stockinet through which the incision is made in the skin and subcutaneous tissues. Stockinet is then fastened over the skin edges with clamps to exclude operative field from surrounding cutaneous area.

calcaneocuboid joint is marked on line $D'O'$. The tracing of the os calcis and cuboid is made to rest on this point, the plantar surface of the os calcis and the head of the fifth metatarsal are made to rest on the base line, $A'C'$. Line GH on the tracing of the astragalus and tibia is superimposed over line $G'H'$.

The Relationship of the Talus to the Os Calcis—The importance of providing for a proper distribution of forces between the heel and the forefoot has been

repeatedly emphasized in the literature. An understanding, of practical value, can be gained from the measurements made on tracings of x-ray negatives made of thirty-two cadaver feet.

Referring to Fig. 4, the average length of DA is 5.5 cm, the average for DG is 2.5 cm. The measured length of $D'A'$ in Fig. 4 is 4.3 cm, while the length of $D'G'$ is X . The equation $2.5 + 5.5 - X = 4.3$ gives a value of 1.9 cm for $D'G'$. At this point $G'H'$ perpendicular is executed for use as previously stated.

The overlap of tracing at respective levels representing articulations represents the amount of bone and cartilage which must be removed. Fig. 5 reveals the preoperative analysis superimposed over the postoperative result.

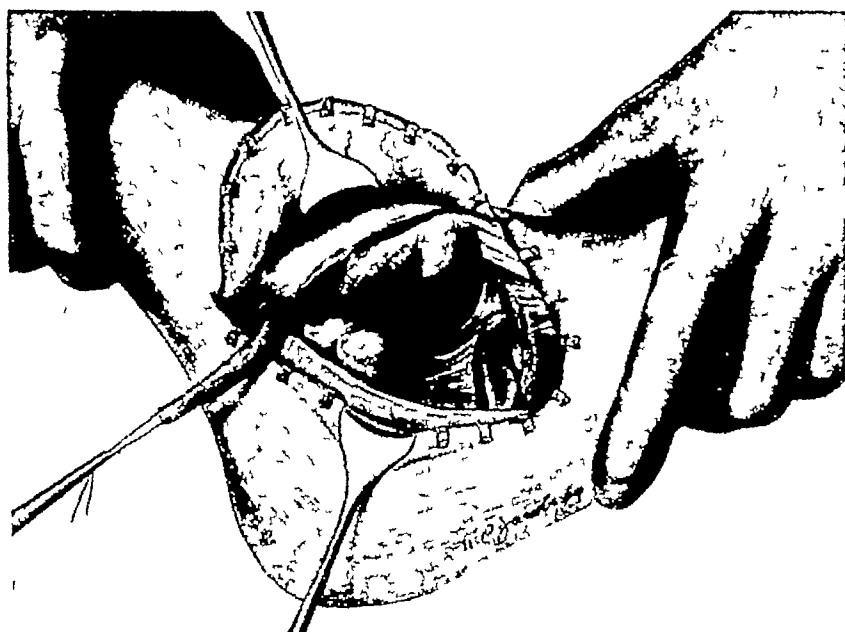


Fig. 8—Adduction and inversion of the forefoot bring simultaneously to view the respective articulating surfaces of each subastragalar joint including the sustentaculum tali.

DESCRIPTION OF OPERATIVE PROCEDURE

Accuracy in performing a subastragalar arthrodesis suggests that the irregularities in shape, contour, size, number, and angulation of the respective articular surfaces should be taken into account. The precise surgical procedures prescribed by preoperative analysis indicate the advantage to be offered by a clear view of each articular surface. The probability of the best functional result following subastragalar arthrodesis is most assured when the operation is performed under these conditions.

The maximum correction of deformity is dependent upon (1) the accuracy of preoperative analysis, and (2) the precision with which bone and cartilage are removed at each of the articulations enumerated. The restoration of stability without pain depends upon precise apposition with accurate alignment of bone surfaces at each of the four places where fusion is desired. The alignment

is necessarily determined by the accuracy with which the respective surfaces of denuded bone fit each other. Meeting these requirements is facilitated by an exposure as illustrated in Fig 6. In the forty-five operations that have been done there has been no complication in healing per primam despite the length and contour of this incision. The foot is enclosed in sterile stockinet as in Fig 7. The simultaneous exposure of all articulations, including the sustentaculum tali, as provided by this exposure is revealed in Fig 8, with no liberties taken by the artist. Familiarity with the shape, contour, and variations frequently en-

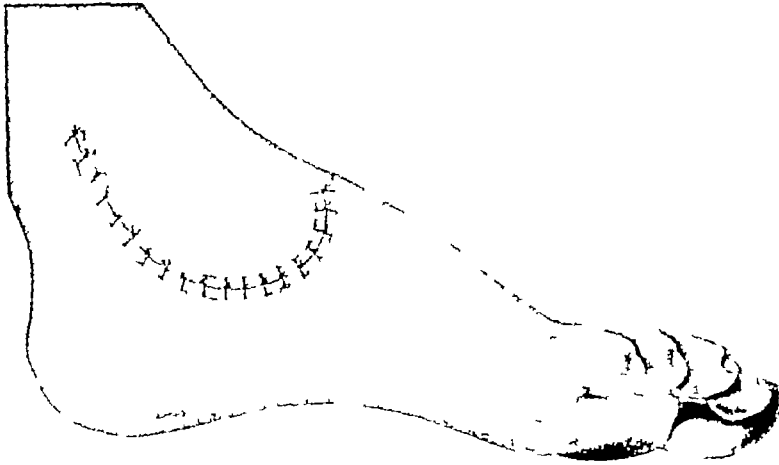


Fig 9—Closure is executed in each plane from ligamentous capsule to skin with interrupted black silk suture.

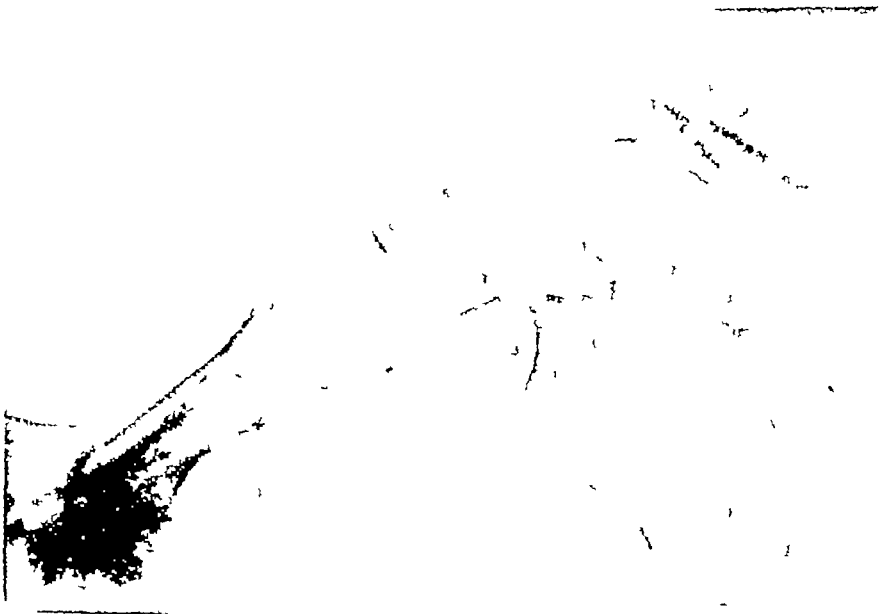


Fig 10—Preoperative mediolateral roentgenogram right foot.

countered at respective articulations can be exercised through such a single and complete exposure. This advantage together with information provided from the preoperative analysis gives maximum resources for the prevention of errors of commission or omission in the removal of cartilage and bone at respective levels.



Fig. 11.—Postoperative mediolateral roentgenogram right foot (seven months)



Fig. 12.—Preoperative determination superimposed over postoperative roentgenogram right foot as shown in Fig. 11

With or without kangaroo suture of cuboid to os calcis the soft tissues are closed from without with interrupted A black silk sutures, in a field essentially dry

With heel and forefoot in neutral position as to varus or valgus, and the foot at 90 degree angle with the leg, it is fixed, with plantar support to the toes, in a plaster cast to the mid-thigh, with knee flexed to 15 degrees. Suspension for one week is indicated to minimize swelling. Immobilization in plaster is continued until x-ray negatives reveal definite evidence of fusion at all levels in both views, time interval has been ten to twelve weeks for beginning weight-bearing without cast

SUMMARY

1 Major deformities of the foot can be most effectively corrected by operation which includes arthrodeseis of the subastragalar and midtarsal joints

2 As indicated by the accompanying review of the literature, the importance of this procedure is second only to the emphasis placed upon those principles which should be followed in the operative procedure, to assure the best end result

3 To facilitate the application of those principles, a method of preoperative analysis of the particular deformity is described herewith. Through its application in successive instances there is gained an understanding of requirements which leads to postoperative relationships which very closely approach the preoperative relationships which are the best which can be executed in the particular instance

4 The use of an incision, such as the one illustrated, which will provide simultaneous and full exposure of all articulations, is regarded as of primary importance in the application of both those principles and the information gained by preoperative analysis

5 These two resources have been applied in the correction of deformities, with or without instability, of forty-five feet. The end results were uniformly superior to twenty-one patients where preoperative analysis was not practiced and the operation was a relatively "blind procedure" through short unilateral or bilateral incisions. The adequate exposure described herewith healed per primam in each instance

REFERENCES

- 1 Ogston, A. Improved Method of Treating Club Foot, Edinburgh M J 24 481 492, 1878 79
- 2 Albert, E. Zur Resektion des Kniegelenkes, Wien med Presse 20 705, 741, 1879
- 3 Von Lesser, L. Ueber operatione Behandlung des Pes Varus Paralyticus, Centralbl f Chir 6 497 500, 1879
- 4 Broca, A. Sur un pied creux talux, Progres med, Par 12 775, 1884
- 5 Zinsmeister, O. Ueber die operative Behandlung paralytischer Gelenke (Arthrodese), Deutsche Ztschr f Chir 26 498 1887
- 6 Karsewski, F. Ueber Operationen an paralytischen Gelenke, Deutsche med Wchnschr 16 63 66, 90 95, 1890
- 7 Gluck, T. Die Invaginationsmethode der Osteo und Arthroplastik, Verhandl d Berl med Gesellsch 21(2T) 130 154, 1890 (1891)
- 8 Kirmisson, M. De l'arthrodese, Bull med, Paris 5 601, 1891
- 9 Whitman, Royal. The Operative Treatment of Paralytic Talipes of the Calcaneus Type, J A M A. 122 593 601, 1901
- 10 Whitman, Royal. The Operative Treatment of Paralytic Talipes of the Calcaneus Type, J A Orth Ass 14 178 187, 1902

- ✕ 11 Kocher, E T Operative Surgery, Stile's English Translation of Fourth German Edition, London, 1903, A. & C Black, Ltd, pp 347 348
- ✕ 12 Aitken, D Macrae A Note on the Variations of the Tibia and Astragalus, J Anat & Physiol 39 489, 1905
- 13 Steindler, A A Textbook of Operative Orthopedics, vol 10, New York, 1925, D Appleton & Co, pp 243 246
- N.A. 14 Townsend, W R Treatment of Paralytic Club Foot by Arthrodesis, Am J Orthop Surg 3 378 391, 1905
- ✓ 15 Dwight, T Clinical Atlas, Variations of the Bones of the Hand and Foot, Philadelphia, 1907, J B Lippincott Company, Fig 52, plate XXIII
- ✕ 16 Dwight, T Clinical Atlas, Variations of the Bones of the Hand and Foot, Philadelphia, 1907, J B Lippincott Company, p 16
- ✕ 17 Piersol, G A Human Anatomy, Philadelphia, 1907, J B Lippincott Company, p 425
- N.A. 18 Goldthwait, J E An Operation for the Stiffening of the Ankle Joint in Infantile Paralysis, Am J Orthop Surg 5 271, 1908
- N.A. 19 Jones, R J An Operation for Paralytic Calcaneo Cavus, Am J Orthop Surg 5 371 376, 1908
- ✓ 20 Whitman, Royal Further Observations on the Operative Treatment of Paralytic Talipes of the Calcaneus Type, Am J Orthop Surg 8 137 144, 1910
- ✕ 21 Lorthoir, J Hunt cas d'arthrodèse du pied avec extirpation temporaire de l'astragala, J de Chir et Ann Soc belge de chir 11 184 187, 1911
- 22 Soule, R E Arthrodesis of Some of the Smaller Joints in the Treatment of Paralytic and Acquired Deformities, J A M A 58 1440, 1912
- ✓ 23 Davis, G Treatment of Hollow Foot (Pes Cavus), Am J Orthop Surg, Phila 2 231 242, 1913
- ✓ 24 Broca, A L'Arthrodèse du pied, Presse méd 25 444-445, 1917
- N.A. 25 Dunn, N Calcaneo Cavus and Its Treatment, Am J Orthop Surg 1 711 721, 1919
- 26 Sever, J W Removal of the Astragalus in Paralytic Feet, J A M A 75 1200, 1920
- 27 Lovett, R W The Operative Treatment of Infantile Paralysis, Surg, Gynec & Obst 32 20, 1921
- 28 Samter Referred to by Ombrédanne 31
- 29 Stokes Referred to by Ombrédanne 31
- N.A. 30 Hoke, M An Operation for Stabilizing Paralytic Feet, Am J Orthop Surg 3 494 507, 1921
- 31 Ombrédanne, L Les Arthrodèses du Pied, Rev d'orthop, Ser 3, 8 515 576, 1921
- 32 Whitman, Royal Critical Comments on a paper entitled "Astragalectomy in Paralytic Feet," J Orthop Surg 3 18 22, 1921
- 33 Dunn, N Stabilizing Operations in the Treatment of Paralytic Deformities of the Foot, Proc Roy Soc Med (Sec Orthop) 15, 15 22, 1922
- N.A. 34 Whitman, A Astragalectomy and Backward Displacement of the Foot An Investigation of Its Practical Results, J Bone & Joint Surg 20 266 278, 1922
- N.A. 35 Steindler, A The Treatment of the Flail Ankle, Pan Astragaloid Arthrodesis, J Bone & Joint Surg 5 284 294, 1923
- N.A. 36 Rejerson, E W Arthrodesing Operations on the Feet, J Bone & Joint Surg 5 453 471, 1923
- 37 Satta, F Considerazioni critiche sull' astragalectomia nei piedi paralitici, Chir d org di movimento 9 37 48, 1925
- N.A. 38 Brown, L T The End Results of Stabilizing Operations on the Foot, J Bone & Joint Surg 6 830 846, 1924
- ✓ 39 Crainz, S L'arthrodèse del piede per mezzo dell'astragalectomia seguita da reimpanto parziale o totale dell' astragalo, Policlinico 31 15, 1924
- ✓ 40 Smith, A de F, and von Lackner, H L Subastragaloid Arthrodesis, A Study of End Results, Surg, Gynec & Obst 40 836 841, 1925
- ✕ 41 Van Assen, J Stabilization of Paralyzed Foot, Ztschr f orthop Chir 50 543 548, 1928
- N.A. 42 Dunn, N Suggestions Based on Ten Years' Experience of Arthrodesis of Tarsus in Treatment, Robert Jones Birthday Volume, London, 1928, Oxford University Press, pp 395 407
- ✓ 43 MacAusland, R Subastragalar Arthrodesis, Arch Surg 18 624 644, 1929
- 44 Kortzborn, A Beitrag zur Arthrodèse des Fusses. (Furnier Plastik nach F Schultze), Chirurg 1 209, 1929
- 45 Graham, W F, and Falkner, D M Astragalectomy, Ann Surg 89 435 438 1929
- 46 Ombrédanne, L Sur le Prélèvement des greffons destinés à établir des buttes astragaliennes, Presse méd 37 516, 1929
- 47 Rawson, J D Orthopedic Surgery in Pes Cavus Semana med 1 1655 1665 1929
- ✓ 48 Maver, L Operative Treatment of Paralytic Deformities Am J Surg 7 50 55 1929

- ✓ 49 Beykirch, A Etiology and Treatment of Hollow Claw foot, *Ztschr f orthop Chir* 52 41 39 1929
- ✓ 50 Kinder, F C The Prehallux (Accessory Scaphoid) in Its Relation to Flat Foot, *J Bone & Joint Surg* 11 831 837, 1929
- ✓ 51 Del Rio, M L'Astraglalectomia temporanea sperimentale, *Arch Soc ital d chir* 35 860 863, 1929
- ✓ 52 Jones, R, and Lovett, R W Orthopedic Surgery, Ed 2, Revised, New York, 1929, William Wood & Company, pp 486 487
- ✓ 53 Andrew F D, and Warren, S L Study in Distortion in Roentgenograms Taken at Various Distances *Am J Roentgenol* 22 332 1929
- ✓ 54 Campbell, W C Operation for Induction of Osseous Fusion, *Am J Surg* 6 538 1929
- ✓ 55 Bullitt, J B Variations of the Bones of the Foot Fusion of Talus and Navicular, Bilateral and Congenital, *Am J Roentgenol* 20 548, 1928
- ✓ 56 MacAusland W R Subastragalar Arthrodesis *Arch Surg* 18 624, 1929
- ✓ 57 Friedland, M Method of Arthrodesis of Tarsus, *Arch f Orthop* 27 240, 1929
- ✓ 58 Lamy, L Treatment of Talipes Equinovarus by Subcutaneous Excision, *Semaine d'hop de Paris* 6 168 175, 1930
- ✓ 59 Cole W H Bone Fixation of Foot in Infantile Paralysis Subastragalar Arthrodesis, *J Bone & Joint Surg* 12 289 298 1930
- ✓ 60 Treves, D Treatment of Talipes Equinovarus, *Bull et mem Soc de chir de Paris* 22 597 601, 1930
- ✓ 61 Roederer C Methods of Early Treatment in Talipes Equinovarus, *Bull et mém Soc de chir de Paris* 22 690 1930
- ✓ 62 Judet, H, Massari, R, and Treves, A A propos du traitement du pied bot varus equin chez le nourrisson, *Bull et mém Soc de chir de Paris* 22 647 650, 1930
- ✓ 63 Levashoff, E A Arthrodesis by Lorthuor Modified Method *Ortop i travmatol* 4 22 27 1930
- ✓ 64 Nutter J A Treatment of Fractures of Os Calcis by Arthrodesis of Subastragalar Joint, *Canad M A J* 22 247, 1930
- ✓ 65 Campbell W C Bone block Operation for Drop foot, Analysis of End results, *J Bone & Joint Surg* 12 317 1930
- ✓ 66 Buzbr, B F Results of Stabilizing Operations on the Feet, *J M Soc New Jersey* 27 316, 1930
- ✓ 67 Snow L C Mechanical and Anatomical Principles of Operations for Foot drop, Suggested New Operations *Surg, Gynec & Obst* 51 252 1930
- ✓ 68 Whitman A Modified Loop Operation for Relief of Paralytic Equinovalgus, *J Bone & Joint Surg* 13 122 126 1931
- ✓ 69 Patel Crushing Fracture of Calcaneum Repaired by Subastragalar Arthrodesis, *Case, Lyon chir* 28 113 114 1931
- ✓ 70 Whitman A Astragalectomy Ultimate Result, *Am J Surg* 11 357 358, 1931
- ✓ 71 Michel L Technique and Results of Subastragalar Arthrodesis and Paramediotarsal Excision in a 2 Year Old Child With Congenital Talipes Equinovarus, *Case, Rev d'orthop* 18 145 154 1931
- ✓ 72 Lange, F Arthrodesis, *Deutsche Ztschr f Chir* 164 785 797 1931
- ✓ 73 Diessl F Results of Arthrodesis, *Beitr z klin Chir* 152 487-494 1931
- ✓ 74 Seiffert, K Advantages of Arthrodesis in Severe Paralysis, *Beitr z klin Chir* 152 495 501, 1931
- ✓ 75 Chutro P Astragalectomy by Fragmentation, *Rev de cir, Buenos Aires* 10 173 183 1931
- ✓ 76 Treves, A Treatment of Congenital Talipes Equinovarus *Rev d'orthop* 18 393-456, 1931
- ✓ 77 Nove Jossierand, G and Michel L Subastragalar Arthrodesis and Paramediotarsal Excision of Clubfoot in Child of 4 Years, *Rev med. franç* 12 673 678, 1931
- ✓ 78 Wagner, L C Modified Bone Block (Campbell) for Paralytic Drop foot With Report of 27 Cases *J Bone & Joint Surg* 13 142 1931
- ✓ 79 Contarginis, A Correction of Drop foot by Posterior Arthrodesis, *J Bone & Joint Surg* 13 54, 1931
- ✓ 80 Maltner, L J Stabilization of Foot—Study of Late Results, *J Bone & Joint Surg* 13 502, 1931
- ✓ 81 Coenen, H Arthrodesis Performed by Splintering Bone, *Arch. f klin Chir* 170 324 330, 1932
- ✓ 82 Odasso, A. Astragalectomy, *Boll e mem Soc piemontese di chir* 2 1212 1218, 1932
- ✓ 83 Zaremba, J Astragalectomy and Its Application in Orthopaedics, *Chir narz ruchu* 5 313 322, 1932
- ✓ 84. Moreno M Ruiz Astragalectomy in Talipes Equinovarus in Child, *Bol y trab, Soc de cir de Buenos Aires* 16 40 45 1932,

- ✓ 85 Ducroquet, R Mediotarsal Subastragular Arthrodesis (Ducroquet Launay operation), *Prat mcd franç* 13 459 462, 1932
- ✓ 86 Blanco, J Lite Nove Josseland, Technique of Subastragular Arthrodesis and Para mediotarsal Excision in Paralytic Talipes Quinus, *Clin v lab* 20 144 145, 1932
- ✓ 87 Bengen, L Zur operativen Behandlung des Hackenhohlfusses, *Verhandl d deutsch orthop Gesellsch* (1931) *Kong* 26 407 411, 1932
- ✓ 88 Massart, R Astragalectomy, Indications and Remote Results, 20 Cases, *Bull et mém Soc de chir de Paris* 25 158 173, 1933
- ✓ 89 Vidal Naquet, G Arthrodesis by Transarticular Fixation, *Bull et mém Soc de chir de Paris* 25 11 120, 1933
- ✓ 90 Lambrinudi, C Method of Correcting Equinus and Calcaneus Deformities at Subastragaloid Joint, *Proc Roy Soc Med* 26 788 791, 1933
- ✓ 91 Tamini, L Astragalectomy in Talipes Equinovarus in Child, *Bol v trab, Soc de cir de Buenos Aires* 17 71 72, 1933
- ✓ 92 Massart, R, and Vidal Naquet, G L'Astragalectomie (ses indications et ses résultats) *J de mcd de Paris* 53 459 460, 1933
- ✓ 93 Massart, R, and Vidal Naquet, G Method of Arthrodesis by Transarticular Pegging, *Rev gen de clin et de therap* 47 385 387, 1933
- ✓ 94 Morris, R H Foot Stabilization, Result of 52 Operations, *New England J Med* 209 78 83, 1933
- ✓ 95 Brewster, A H Countersinking Astragalus in Paralytic Feet, *New England J Med* 209 71 74, 1933
- ✓ 96 Seddon, H J Calcaneo Scaphoid Coalition, *Proc Roy Soc Med* 26 419, 1933
- ✓ 97 Mayer, L Correction of Severe Equinus Deformity, *J Bone & Joint Surg* 16 46 52, 1934
- ✓ 98 Curtis, F E, and Muro, F Decancellation of Os Calcis, Astragalus, and Cuboid in Correction of Congenital Talipes Equinovarus, *J Bone & Joint Surg* 16 110 118, 1934
- ✓ 99 Schotte, M Studie zur Behandlung des Hohlfusses, *Deutsche med Wehnschr* 60 820 822, 1934
- ✓ 100 Turner, H Deformities of Foot Associated With Arthrodesis of Ankle Joint Performed in Early Childhood, *J Bone & Joint Surg* 16 423, 1934
- ✓ 101 Wescott, H H Operation for Fusion of Tibio Astragaloid Joint, *Virginia M Monthly* 61 38, 1934
- ✓ 102 Hamsa, W R Panastragaloid Arthrodesis, End Results in 85 Cases, *J Bone & Joint Surg* 18 732, 1936
- ✓ 103 Forrester Brown, M Arthrodesis in Young Children, *Proc Roy Soc Med* 30 432 1937
- ✓ 104 MacAusland, W R Subastragular Arthrodesis in Paralytic Deformities, *Ann Surg* 105 452, 1937
- ✓ 105 Butte, F L Navicular Cuneiform Arthrodesis, End result Study, *J Bone & Joint Surg* 19 496, 1937
- ✓ 106 Hart, V L Arthrodesis of Foot, *Surg, Gynec & Obst* 64 794, 1937
- ✓ 107 MacAusland, W R Subastragular Arthrodesis, *Am J Surg* 43 535, 1939
- ✓ 108 Shands, A R, Jr Stabilization of Joints in Childhood, *Delaware State M J* 11 231, 1939
- ✓ 109 Liebold, F L Pantalar Arthrodesis, *SURGERY* 6 31, 1939
- ✓ 110 Hatt, R N Central Bone Graft in Arthrodesis, *J Bone & Joint Surg* 22 393, 1940
- ✓ 111 Leavitt, D G Subastragaloid Arthrodesis for Os Calcis Type of Flat Foot, *Am J Surg* 50 501, 1943
- ✓ 112 Creer, W S Modified Subtaloid Arthrodesis, *Proc Roy Soc Med* 36 333, 1943
- ✓ 113 Galhe, W E Subastragular Arthrodesis, *J Bone & Joint Surg* 25 731, 1943
- ✓ 114 Miller, O L Surgical Management of Pes Calcaneus, *J Bone & Joint Surg* 18 169, 1936

ADAMANTINOMA OF THE MAXILLARY SINUS

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ADAMANTINOMA involving the maxillary sinus is uncommon in the experience of most rhinologists. When first encountered, therefore, the true nature of the tumor may not be recognized and inadequate surgical measures may be employed. The clinical picture may readily be mistaken for malignancy of the antrum and even the microscopic examination in cases of the undifferentiated types of this tumor may be misleading.

Definition and Classification—The adamantinoma may be defined according to Robinson¹ as an 'epithelial tumor arising from the odontogenic apparatus or from cells with a potentiality for forming tissues of the enamel organ.' The first complete description is usually credited to Falkson in 1879. Malassez who described the tumor in 1885 introduced the name adamantinoma and this term has been widely used in the literature although admittedly misleading inasmuch as the tumor never forms enamel (adamantine) tissue. Thoma² prefers the term adamantoblastoma in view of the fact that the parent epithelium has the "power to differentiate into enamel epithelium without actually forming enamel." Robinson and Churchill designated the tumor as ameloblastoma deriving the term from ameloblast, the enamel-forming cell. The name adamantinoma will be retained in this paper because of its common usage and wide familiarity. This tumor is classified with the epithelial odontomes which also include other tumors of the odontogenic apparatus such as dentigerous and dentoperiosteal cysts.

Pathogenesis—The most widely accepted view at present is that the adamantinoma arises from paradental epithelial rests. Malassez first observed cord-like and glandlike groups of epithelial cells around the roots of the teeth and considered them to represent vestiges of the rich dental apparatus of the lower vertebrates. These cells are derived from the enamel organ and were named by him "paradental epithelial debris." Malassez demonstrated that these cells may remain as scattered epithelial rests even late in life. Under certain irritative conditions, he felt, these cells become proliferative and give rise to tumor formation. It is a clinical fact that many reported cases have recorded preceding traumatic or irritative factors in the form of dental extraction, injury to the jaw, impaction, or infection.

Clinical Pathology—The adamantinoma, according to Robinson, is characteristically "unicentric, nonfunctional intermittent in growth, anatomically benign and clinically persistent." It is usually a central tumor. Two types are recognized: the *cystic* tumor (mono- or polycystic) which is far the more common and the rarer, *solid* variety. It is important to point out that maxillary tumors are more often of the solid type than those involving the mandible. It

must also be emphasized that no entirely accurate differentiation can be made on this basis alone inasmuch as many intermediate forms are found in which one portion of the tumor is solid and another cystic. Most adamantinomas are of the polycystic variety. In 219 cases reviewed by Robinson, 57.5 per cent were cystic, 24.2 per cent both cystic and solid, and 19.1 per cent solid. Teeth are frequently found in these tumors and may cause a mistaken diagnosis of dentigerous cyst. The solid tumor is usually white or reddish in color, of fine granular consistency, and definitely encapsulated. In the cystic type, compartments of varying size are noted, some filled with solid tumor and others with a thin yellowish fluid. Fibrous or bony septa can be seen separating the various cysts.

Macroscopically, the solid areas consist of a fibrous tissue stroma and columns of epithelial cells which may be elongated, rounded, or arranged in acini-like forms. Two types of epithelial cells are found in these cell columns: the typical columnar cell and the characteristic differentiated polygonal and stellate cells which form the main mass of the epithelial columns. These cells are analogous to the cells that form the enamel organ. The stellate cells undergo disintegration and gradually disappear, leaving cysts containing fluid and lined with columnar cells. In the larger cysts the walls consist of fibrous tissue only. Authorities agree that no information can be gained from the microscopic picture concerning the malignant potentialities of the tumor although Ewing³ considers the solid tumors to be more malignant than the cystic types.

Most adamantinomas, as Calvin has pointed out, grow slowly and distend the jaw more than they destroy it. Anatomically they are usually benign but malignantly infiltrative varieties occur in the maxillary sinus which may involve the orbit, nasopharynx, and intracranial structures. Robinson in his review found seventeen cases of malignant adamantinomas, an incidence of 4.5 per cent. Both carcinomatous as well as sarcomatous changes have been reported. One rare case of melanotic adamantinoma was described in 1926 by Mummery and Pitts. Phelps⁴ in 1939 reported a case of malignant adamantinoma with metastases to the liver, lungs, ribs, and clinically to the left retina. Havens⁵ believed that these tumors should be classified as malignant in view of their persistent recurrence if incompletely removed as well as their possibilities for metastases. He reported one case in the lower jaw with metastases to the submaxillary and upper cervical lymph nodes and noted two other cases with similar glandular involvement. All authorities, however, agree that the lymph nodes are rarely involved except by malignant recurrences. Metastases to the lungs have been described by several writers and in certain instances, according to Thoma, were probably due to inhalation implantation.

Clinical Considerations —

Age Adamantinomas, while uncommon in the experience of most rhinologists, are not as rare as is generally believed. Robinson in 1937 was able to collect reports on 379 cases from the world literature. The analysis of these cases contains several points of clinical interest. 54.3 per cent occurred in females. There was no evidence of any racial preference. The age incidence

varied greatly. The average age at the time of reporting was 37.6 years. The average duration between the time of reporting and the time of discovery was 8.5 years and the average age at the time of discovery was 30.1 years. In 70 per cent of these cases the growth was first noticed between the tenth and the thirty-fifth years. Cases, however, have been reported in early childhood and Massin described a case occurring in a newborn infant. Lewis described a growth in a patient 75 years of age. Ewing expressed the opinion that these tumors begin much earlier in life than is generally recognized but because of their slow growth may not be clinically apparent until middle or later life. Murphy⁶ stated that the semisolid tumors evolve in from one to fifteen years, the purely cystic in from ten to twenty years, further, that the unilocular type averages ten years in its development and the multilocular fourteen to fifteen years. Murphy also noted that the solid variety was more common in younger patients and the cystic more frequent in later life. It may be accepted, therefore, as a clinical fact that adamantinomas exist for a long period before giving rise to definite symptoms.

Location Adamantinoma is more commonly encountered in the mandible than in the maxilla. In Robinson's review, 83.7 per cent occurred in the lower jaw. In a series of fifty-eight cases reported by Havens from the Mayo Clinic only five involved the upper jaw. Interesting recent reports of this tumor involving the maxillary sinus have been made by Phelps (1939),⁴ Golden (1942),⁷ and Mosher (1944).⁸ Ewing and Murphy both agree that solid adamantinomas are more frequent in the upper jaw and, further, that this location shows a greater incidence of the malignant forms.

Symptomatology The adamantinoma is a slow-growing, centrally expansive tumor. In the upper jaw the relatively large dimensions of the maxillary sinus permit great expansion of the growth before its presence is clinically apparent. Early diagnosis is uncommon and ill-defined pressure pains are usually mistaken for dental causes. Roentgenograms in this early stage are inconclusive. Slow expansion of the facial and nasal walls of the maxilla with resulting deformity of the face and obstruction of the nasal passage is commonly the chief presenting symptom. At this stage the thin, parchmentlike bony capsule, crepitating on pressure, is often noted. Pain is usually slight except in the more advanced tumors. Occasionally a cystic tumor may rupture into the mouth, causing the patient to seek advice because of the persistent oral drainage. Extension into the orbit with exophthalmos and into the nasopharynx with dysphagia has also been reported (Ewing). Broadening of the alveolar ridge with displacement of the adjacent portion of the hard palate may occur.

Diagnosis—The diagnosis of adamantinoma is suggested by the slow, frequently painless development of the tumor, by the absence of evidence of soft tissue invasion, by the crackling sensation which can commonly be elicited on palpation over prominent portions of the tumor, by the usual absence of regional glandular involvement (exceptions to this have been pointed out), and finally by the roentgenogram in which the multilocular cystic arrangement of the bony shell and trabeculae is characteristic. The tumor is often clinically mistaken for malignancy of the antrum and the roentgenographic signs of destruction of

portions of the bony walls without evidence of trabeculation may strongly suggest this diagnosis. Malignancy, however, differs in the rapidity of its growth, the early evidence of glandular metastasis, the frequency of evidence of soft tissue invasion, as well as the absence of eruption. Dentigerous cysts may also prove confusing, especially in view of the fact that teeth are frequently found in adamantinomas. Oesterreich in 1936 emphasized this point and reported three cases which were roentgenographically diagnosed as cysts but which on histologic examination proved to be adamantinomas. Ewing also recorded two instances of monocystic adamantinomas clinically mistaken for periodontal cysts. Adamantinoma in his opinion must "always be kept in mind even if the roentgen film shows a monocystic defect or if the cyst contains a tooth."

Prognosis—The adamantinoma must be regarded as a slow-growing expansive tumor with a strong tendency to recurrence. In Robinson's review of 379 cases, recurrences were reported in 119 cases in which from one to twenty-two recurrences were noted. Incomplete removal tends to disrupt the expansive growth of the tumor and induces a more malignant and infiltrating variety which in the maxilla may eventually involve inaccessible and ultimately fatal locations. Recurrence is frequently caused by the spread of the tumor into the spongiosa or haversian system of the surrounding bony cortex as well as by small tumor rests not easily accessible to surgical removal. It is generally agreed that the prognosis in the solid type of tumor is not as favorable as in the cystic variety. Unilocular cystic tumors as well as multilocular tumors with few compartments are more easily completely eradicated than honeycomb tumors with numerous small scattered loculi. Ewing stated that "tumors of the upper jaw are much the more serious and that the solid adamantinomas of all types recur locally and involve antrum, orbit, and nasopharynx. In spite of their relatively benign structures, the prognosis in this group is unfavorable." All authorities agree that any adamantinoma in which the rate of growth is suddenly increased should be given a guarded prognosis because of the strong likelihood of malignant changes.

Treatment—Complete and radical removal of the tumor is necessary because of the clinical certainty that recurrences will occur if small areas remain. Although the adamantinoma is properly considered as a benign tumor by the pathologist, it is better for the rhinologist to treat it as a malignant growth from the outset and to employ radical measures for its complete removal. Perhaps the greatest difficulty in this respect is caused by the tendency of the tumor to proliferate in the spongiosa or the haversian system of the surrounding bony cortex. Both Thoma and Havens have stressed this important fact and presented illustrations of the microscopic fingerlike extensions of the tumor into the bone. The literature is rich in examples of the failures of conservative measures. In the series of 166 cases collected from reported sources by McFarland and Patterson⁹ in 1931, there were sixty-five cases in which a variety of conservative methods had been employed and in this group recurrence was reported in 50.7 per cent. Simple curettage will seldom succeed in eradicating this tumor. Havens, reporting in 1939 on the experiences at the Mayo Clinic, urged radical

resection with the meticulous use of surgical diathermy. Waldron¹⁰ similarly stressed the value of surgical diathermy as the method of choice in accomplishing complete removal. The bony wall surrounding the tumor must be removed or cauterized thoroughly and particular care must be directed toward destroying any extension of tumor into the ethmoidal sinuses. Adamantinomas are recognized as extremely resistant to radiation. Nevertheless many authors including Kotary (1936) and Quick (1938) advise the use of radium packs



Fig. 1.—Case 1

following surgical removal as well as intensive postoperative roentgen therapy. The roentgenologists of our own staff feel that postoperative irradiation is of very questionable benefit. Periodic examinations for possible recurrences must be continued for several years following operation because of the fact, already stressed, that the rate of recurrence may be very slow.

CASE REPORTS

CASE 1—H. M., a white Greek woman of 65, was admitted to the Strong Memorial Hospital on Sept. 13, 1943. Two years before, she had noticed a fullness of the right side of

the face and difficulty in breathing through the right side of the nose. She was advised by her physician that a sinus infection was present and had had frequent nasal treatments by several specialists without relief. During the previous year the right side of the face had become increasingly prominent and the right nasal passage completely obstructed. There was no history of regional pain.

On examination there was definite prominence of the right cheek with swelling of the lower eyelid. There was no evidence of soft tissue infiltration nor could any definite bony defect be palpated. No enlargement of the cervical glands was present. The entire lateral nasal wall was pushed over tightly against the nasal septum but no intranasal evidence of infection nor actual tumor invasion was present. The right antrum was completely opaque on transillumination. Roentgenograms showed the right antrum to be greatly enlarged and obscured by a shadow of rather uniform density (Fig 1). No evidence of trabeculation could be seen. Destruction of the medial and lateral walls was noted, together with thinning of the inferior orbital margin. This evidence indicated a tumor of the right antrum with considerable bony destruction.

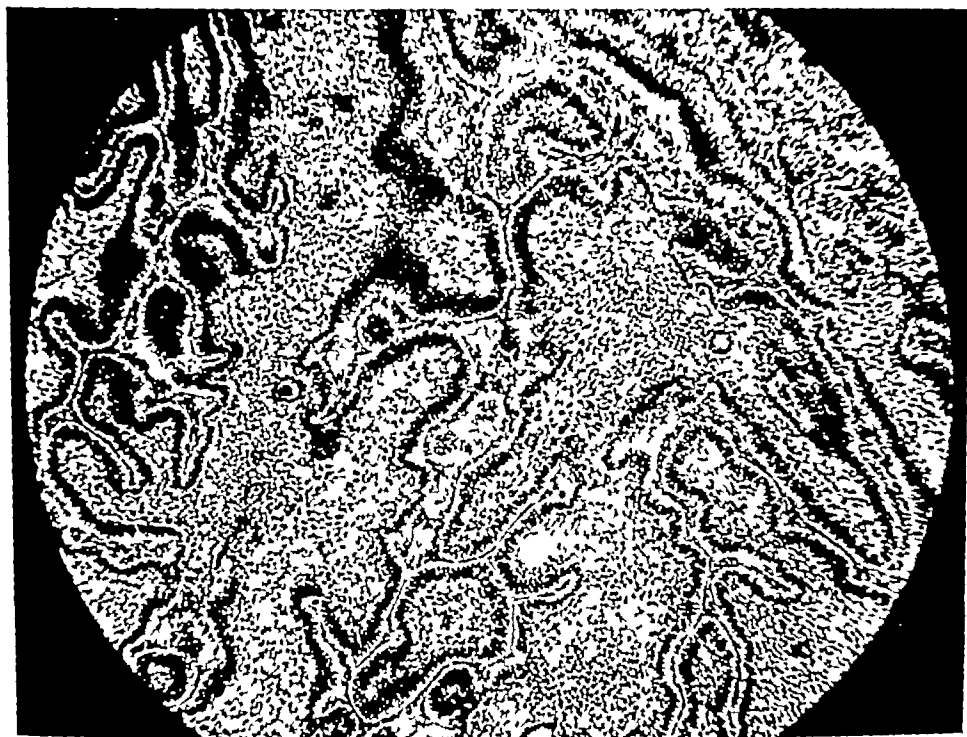


Fig 2—Case 1

A Caldwell Luc operation was performed under sodium pentothal anesthesia. The anterior wall of the maxilla at the point of entrance was markedly thinned and easily entered. The antrum was found to be filled with a whitish, encapsulated tumor of rather firm consistency. A mass about 3 cm in diameter was removed without any troublesome bleeding. The remainder of the tumor was then removed by coagulation. It was noted that this tissue presented a distinctly granular consistency. No large cystic areas were evident. The marked enlargement of the antrum with erosion of the medial and lateral walls noted in the roentgenogram was confirmed. All of the bony walls were greatly thinned. The ethmoid cells were cleaned out as thoroughly as possible through the antrum approach. A large window was resected into the inferior meatus, the wound packed, and the canine fossa incision packed open.

Pathologic Report—Gross specimen revealed a mass of smooth firm whitish tissue measuring about $3\frac{1}{2}$ cm in diameter. It contained small cysts and masses of solid, rather granular tissue.

Microscopic—The tumor had a complex structure which consisted of ramifying columns and masses composed of an outer single row of tall columnar epithelial cells arranged in palisade formation. The central areas were occupied by irregularly arranged stellate cells which stained lighter than the columnar cells. Numerous large and small cysts were seen, these were lined by columnar epithelial cells and contained either a pink coagulum or a delicate stroma of connective tissue and blood vessels. There were areas of fresh hemorrhage and numerous foci of phagocytes containing blood pigment. Diagnosis was adamantinoma (Fig 2).

The patient's postoperative course was uneventful and she was discharged from the hospital on Sept 17, 1943. Follow up was at two month intervals. A small recurrence was observed on April 27, 1944, in the right middle meatus. This was thoroughly destroyed with the diathermy current. Another small mass was similarly removed on Sept 5, 1945, from the inferior meatus. In both instances the recurrent tumor was about the size of a grape. No postoperative irradiation was given in this case because of the opinion of the roentgenologist that it would prove of no value. This patient was examined in January, 1946 and showed no evidence of recurrence. The possibility of further recurrence, however, is considered likely in view of the nature of the tumor as well as its great size.

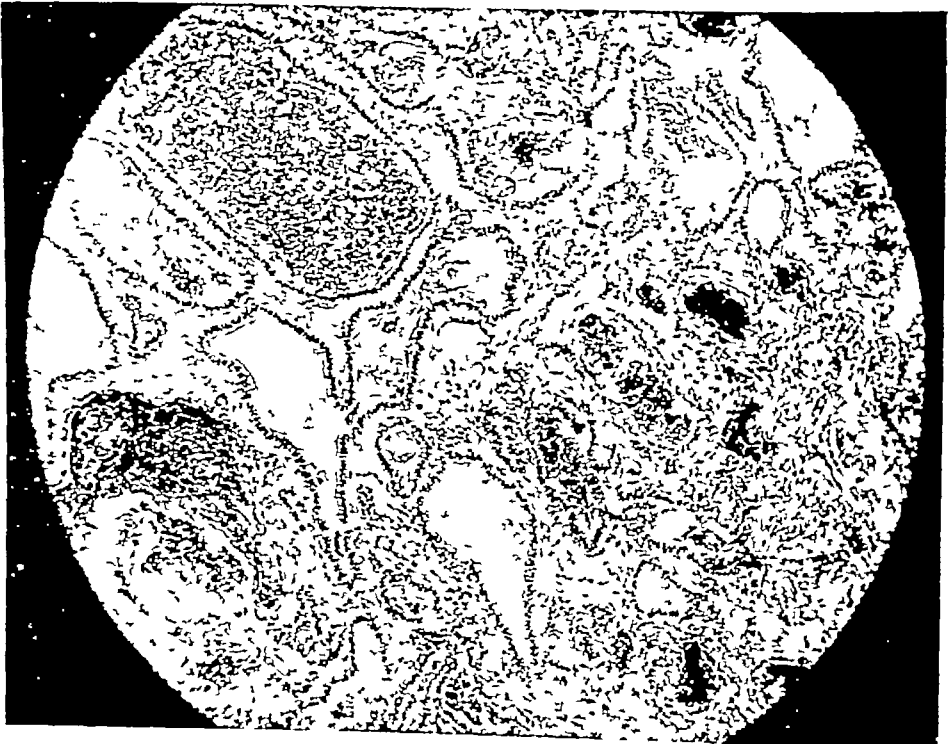


Fig 3—Case 2

CASE 2—C M, a white American man of 65 years, was admitted to Strong Memorial Hospital on Dec 26, 1945, because of a draining sinus from the left antrum into the mouth. Twelve years before, the patient had a wisdom tooth removed from the left upper jaw. The extraction was extremely difficult and the dentist reported that a fragment of bone came away with the tooth. The socket, however, finally healed after about four weeks of treatment.

During the past year the patient had noticed a thin, slightly blood tinged drainage in the mouth. Three months before admission a large opening was observed along the posterior portion of the alveolar ridge and the drainage increased considerably in amount. At the time of entrance into the hospital the drainage had increased to about two tablespoonfuls a day. There had been no pain in the face at any time but some intermittent sense of fullness.

The important clinical findings were as follows: (1) Slight prominence of the left cheek, (2) a large draining sinus opening about 1 cm. in diameter in the approximate position of the left upper third molar, (3) broadening of the alveolar ridge, slight but definite downward displacement of the adjacent hard palate, and definite boggy crepitation on pressure over the palate as well as the anterior wall of the left maxilla, (4) no intranasal changes, (5) completely opaque left antrum on transillumination testing, (6) no enlargement of the cervical glands, (7) roentgenograms showed considerable expansion of the walls of the left antrum with evidence of destruction of the anterior wall and floor. It was considered likely that an expansive and probably cystic tumor of the left antrum, possibly an adamantinoma, was being dealt with.

A Caldwell-Luc operation was performed on Dec. 28, 1945, working with sodium pentothal anesthesia. Most of the anterior wall of the antrum, as well as the greater portion of its floor, was found to be reduced to eggshell thinness and at the point of entrance the bony wall had been completely destroyed. The antrum was filled with a whitish granular tissue containing many small cysts. In the center of the mass was a large cystic cavity which communicated directly with the alveolar sinus. The floor of the orbit as well as the lateral nasal wall was intact but very thin. The tumor tissue was meticulously removed and the ethmoid cells were cleaned out thoroughly. No gross tumor tissue was found in the ethmoid cells. The bone of the anterior wall, as well as the floor of the antrum and the lateral nasal wall, was removed. The diathermy electrode was carefully used throughout the cavity. The sinus tract was dissected out and closed. A large window was resected into the inferior meatus and the canine fossa incision packed open. The postoperative course was uneventful and the patient was discharged from the hospital ten days later.

Pathologic Report—One gram of friable, granular, whitish colored tissue was examined. On microscopic study the tumor had a varied structure. In most areas the tumor consisted of complex, branching columnar structures lined by a layer of tall columnar epithelial cells in palisade arrangement. The central portion of many of the columns contained pale, irregular stellate cells in varying stages of preservation. In others there were cystic spaces, some of which contained pale eosinophilic coagulum, while others were filled by recent and organizing hemorrhage. A few islands of squamous epithelium were seen. There were large areas of degeneration and hyalinization involving tumor cells and stroma. Many chronic inflammatory cells were present in these areas. Diagnosis was adamantinoma (Fig. 3).

COMMENT

These two cases are examples of the solid and polycystic types of adamantinoma. The true nature of the tumor was not recognized in the first case at the time of operation, but was correctly diagnosed in the second instance. The experience gained in the first case as well as a better understanding of the recurrent nature of this tumor prompted a more radical plan of management in the second patient. The possibilities for recurrence, however, in both cases are fully appreciated.

CONCLUSION

Adamantinoma involving the maxillary sinus, while generally classified by pathologists as a benign tumor, should be viewed by rhinologists as a definitely malignant growth in view of its persistent recurrence if incompletely removed. Conservative measures including simple curettage have seldom proved ulti-

imately successful and the resistant nature of the tumor to irradiation is well established. The difficulties of diagnosis as well as complete removal are greater in adamantinomas involving the maxilla than in those originating in the mandible. The sinus cavity permits extensive expansion of the tumor before its presence is clinically suspected and the possibilities for invasion into relatively or absolutely inaccessible areas are far greater. The higher incidence of the dangerous solid type of tumor in the maxilla further increases the difficulties of cure. The value of surgical diathermy both at the time of the original operation as well as in the treatment of recurrences should be recognized. The necessity for frequent re-examination of these patients for many years must also be stressed not only because of the characteristically slow rate of recurrence but also because of the possibilities of frankly malignant changes.

REFERENCES

- 1 Robinson, H. B. G. Ameloblastoma, a Survey of 379 Cases From the Literature, *Arch Path* 23 831-843, 1937
- 2 Thoma, K. H. Oral Pathology, St. Louis, 1941, The C. V. Mosby Company
- 3 Ewing, J. Neoplastic Diseases, Philadelphia and London, 1940, W. B. Saunders Company
- 4 Phelps, K. A. A Case of Malignant Adamantinoma of the Right Maxillary Sinus, *Tr Am Laryng Rhin, & Otol Soc*, pp 393-395, 1939
- 5 Havens, F. Z. Benign Cysts and Adamantinomas of the Jaws *Arch Otolaryng* 30 762-774, 1939
- 6 Murphy, J. T. Adamantine Epithelioma *Radiology* 3 377-387, 1924
- 7 Golden, M. G. Ameloblastoma of the Left Maxillary Sinus, *Ann Otol Rhin and Laryng* 51 378-388, 1942
- 8 Mosher, W. F. Adamantinoma of the Maxillary Sinus, *Arch Otolaryng* 40 61-62, 1944
- 9 McFarland, J., and Patterson, H. M. Adamantinomata. A Review of One Hundred and Ninety Six Cases Reported in the Medical and Dental Literature, *Dental Cosmos* 73 656-670, 1931
- 10 Waldron, C. W. Tumors of the Upper Jaw, *Surg, Gynec & Obst* 72 503-511 1941

AN OPERATIVE PROCEDURE FOR THE REPAIR OF THE URETHRODIVERTICULOVAGINAL FISTULA

REPORT OF TWO CASES

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THE urethrodverticulovaginal fistula is an uncommon lesion. A review of much of the literature on diverticulum of the female urethra and the urethrovaginal fistula revealed but two cases and in one of these, reported by Paimentei, that portion of the tract connecting the diverticulum with the vagina healed spontaneously before the surgical correction of the diverticulum. The first case of this kind that we could find in the literature was reported by Hickinbotham in 1882 and was most interesting. A soft tumor in the proper place for, and resembling, a cystocele was found in a patient 21 years of age just before onset of labor. Ten days after labor, the tumor ruptured and drained a puriform fluid into the vagina. The lesion persisted as a multilocular, mucosal-lined sac in the anterior vaginal wall with a vaginal opening large enough to permit the introduction of the index finger. There was continence of urine and no communication with the urethra could be felt. However, when milk was injected into the bladder and the urethral meatus forcibly closed while the patient attempted to void, some milk found its way into the sac. At operation, a very small urethral opening was found which was covered by a valvular fold of mucosa that prevented leakage into the diverticulum unless the urethra was obstructed distal to it.

From the location and character of the urethrodverticulovaginal fistula, it is reasonable to assume that it can be classified as acquired rather than a congenital lesion. Furthermore, it would seem that the identical conditions which play a role in the development of the urethral diverticulum are the essential factors in its causation. Unless cystic tumors and abscesses between the floor of the urethra and the anterior vaginal wall disappear spontaneously rupture into the urethra or the vagina or both may occur. Due to the relatively greater structural weakness of the urethral mucosa and the periurethral tissues, the break is more frequently into the urethra. In many instances, the lesion develops into a urethral diverticulum because the frequent passage of urine through the urethral channel which has its most narrow portion in the region of the external meatus tends to force urine into the sac beneath and prevents closure before its orifice becomes epithelized. On the other hand because of the more sturdy character of the vaginal mucosa and perivaginal

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structures as well as the presence of a longer drainage tract, epithelization of the tract connecting the sac with the vagina is less liable to occur and closure is more common. It is only in those relatively rare instances where the tracts connecting the sac with the urethra and the vagina become epithelized and their patency is maintained that the methrodiverticulovaginal fistula is formed. We believe the cases presented here to be typical examples of this condition.

CASE 1 (S.M.H. No 192815) — C. G., aged 51 years, a nulliparous married woman with a long history of diabetes mellitus, was admitted to the hospital in June, 1942, complaining of a gradually growing tumor in the anterior vaginal wall. Two weeks before admission the rate of growth had become more rapid, and the tumor became inflamed and very tender. Five days before admission, she developed a low back pain associated with chills and fever and increasingly severe frequency, urgency, and dysuria.

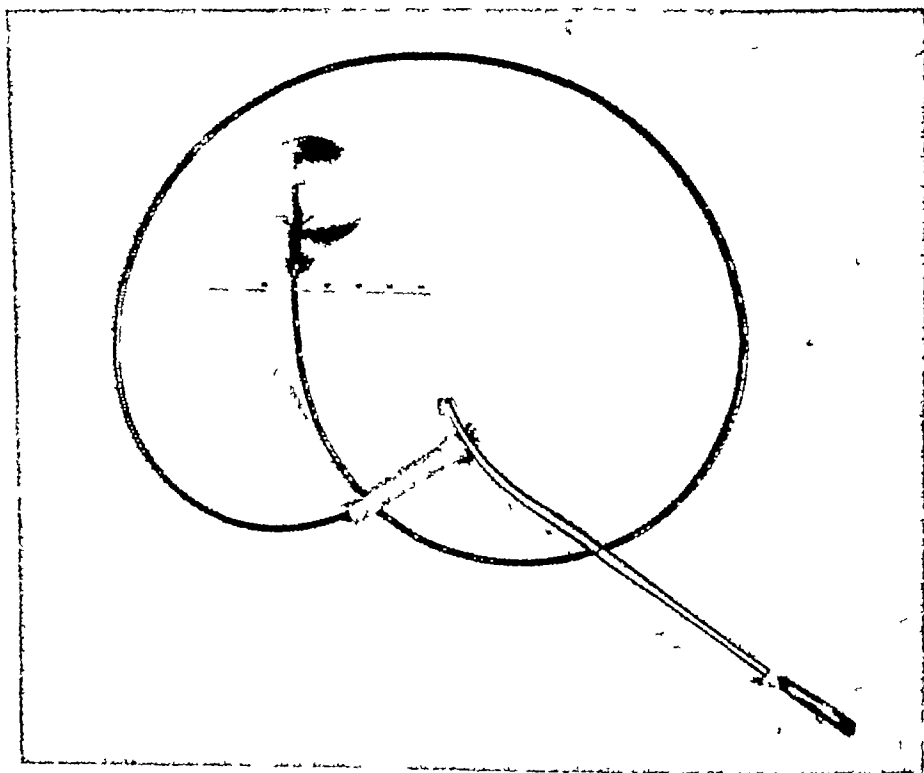


Fig. 1 — Ureteral catheter with distended rubber bag at one end and clamped rubber adapter on the other.

On pelvic examination, swelling of the left labia was observed but Bartholin's glands were normal. Starting just in back of the urethral orifice was a tender, inflamed, smooth mass about 3 cm. wide and 2.5 cm. in depth which extended along the roof of the vagina a little to the left of the midline to within 3 cm. of the cervix. It was thought that this might be an abscess of Skene's gland. As a result of the examination, the tumor was evacuated into the vagina and a hemolytic *Staphylococcus albus* and an alpha prime streptococcus were grown from the purulent discharge. The same organisms were found in the patient's urine. Under a regime of diabetic control and hot vaginal douches, the patient quickly improved and when she was discharged eight days later, there was only a slight vaginal discharge, and she was quite comfortable.

During the next sixteen months, she was seen on several occasions because of a gradually increasing dribble of urine into the vagina. In November, 1943, she was admitted to the hospital for further study and preparation for operation. On vaginal examination, the mucosal surface appeared quite inflamed, probably due to the presence of a fluid discharge which had the appearance and odor of urine. The small orifice of a fistulous tract could be seen on the anterior vaginal wall about 3 cm. from the cervix and about the same distance to the left of the midline.

On cystoscopic examination, the bladder appeared normal, but in the urethra just anterior to the vesical sphincter and in the region of 5 o'clock was the orifice of a deep urethral diverticulum. All efforts to pass a small ureteral catheter through the diverticulum into the vagina were unsuccessful. However, when indigo carmine was injected into the diverticulum some of it appeared at the vaginal orifice of the fistulous tract. A distensible rubber bag was made by tying the lower half of a finger cot over the end of a No. 7 French ureteral catheter. Drainage from the bag was prevented by attaching a rubber adapter and clamping it (Fig. 1). The bag was then introduced through the urethral orifice of the diverticulum and distended with 20 cc. of fluid before the patient felt any discomfort. It could be easily palpated under the trigone with its center a little to the left of the midline. The opinion was that the patient had a urethrodiverticulovaginal fistula (Fig. 2).

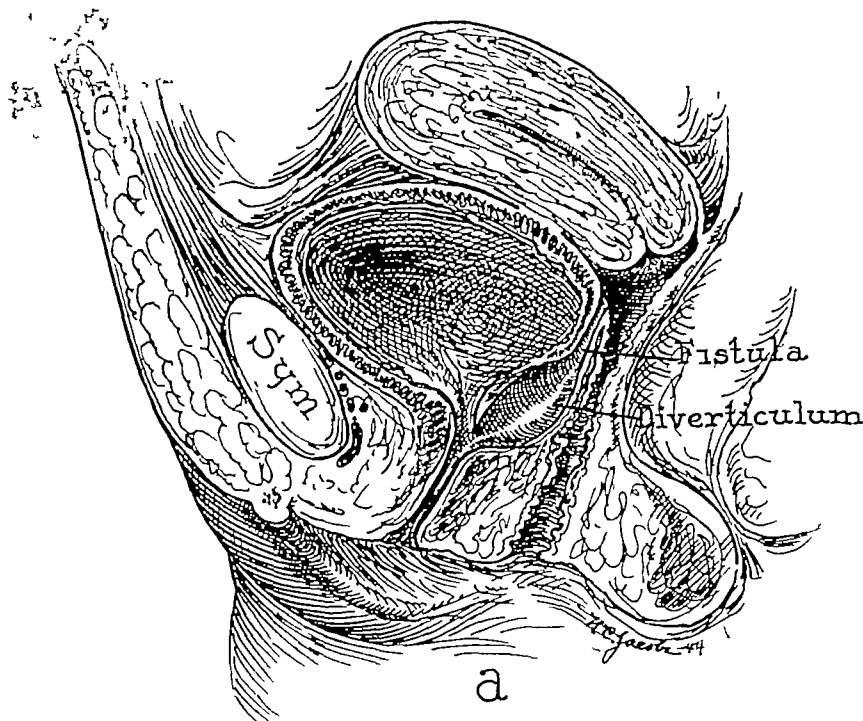


Fig. 2—Schematic representation of lesion found in Case 1

In preparation for operation, the patient's diabetes was controlled by insulin and diet. She was placed on continuous bladder drainage and given vaginal douches with Dakin's solution. The urethra was thoroughly dilated and sulfadiazine was given orally to control the urinary infection. On the second night prior to operation, she was given a cathartic of sufficient strength to assure a copious bowel movement. She was also given an enema the day before and on the morning of operation.

The operation was performed through the vaginal approach under ether anesthesia. With the patient on the Young prostatectomy table, the rubber bag previously described was introduced into the diverticulum, filled with 20 c.c. of water and the adapter clamped.

The patient was then placed in an exaggerated lithotomy position, the vagina cleansed, retractors placed, and traction applied to the cervix by means of a tenaculum. This maneuver made it possible to introduce a filiform through the vaginal orifice of the fistulous tract and into the sac of the diverticulum. It was tied in place by a black silk suture. An incision was made through the vaginal mucosa starting with a cuff around the orifice of the fistula and extending along its course over the center of the bulge caused by the

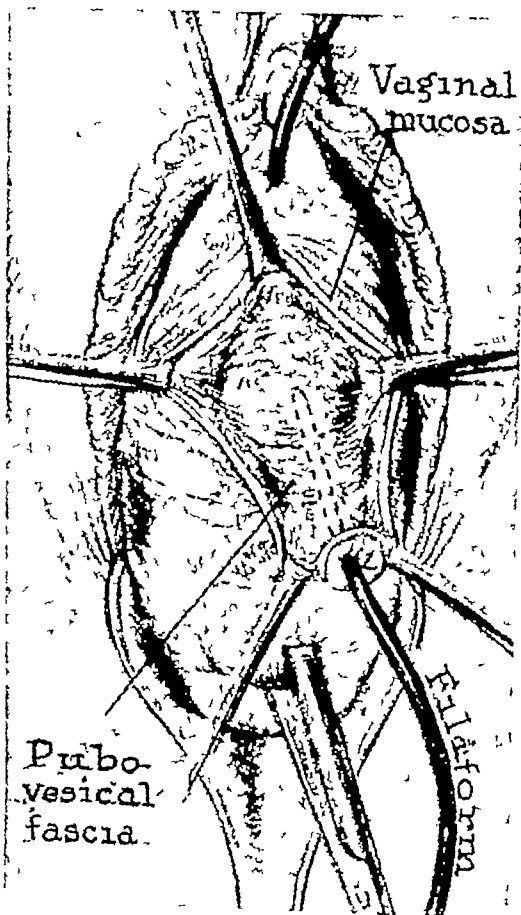


Fig 3

Fig 3—The incision and elevation of the edges of vaginal mucosa over the distended bag in sac of diverticulum and filiform in vaginal tract

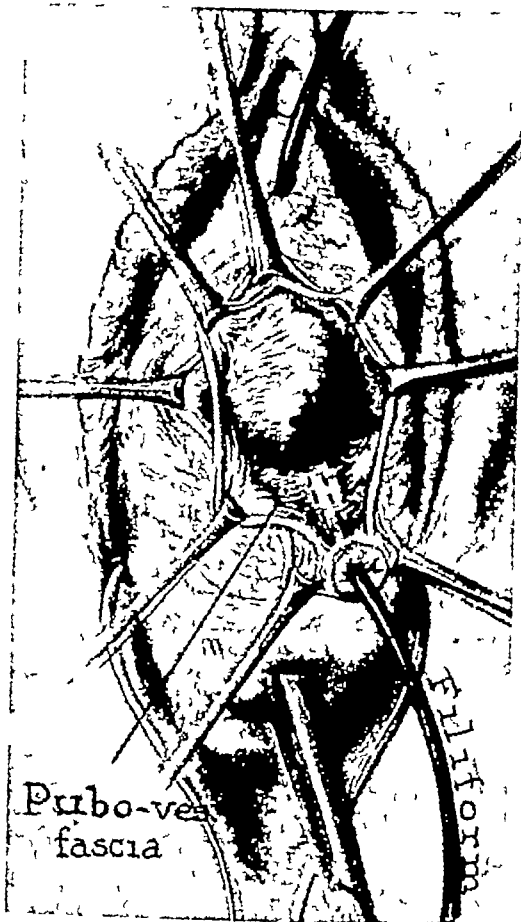


FIG 4

Fig 4—The separation of the pubovesical fascia from the thin epithelial-lined sac of the diverticulum and the vaginal tract.

distended bag to the region of the posterior third of the urethra and just a little to the left of the midline (Fig 3). The margins of the vaginal mucosa were elevated for a little more than 2 cm from the pubovesical fascia beneath in order to obtain a better exposure and to facilitate closure. Then an incision following the same course as that in the vaginal mucosa was made in the pubovaginal fascia. Over the distended diverticulum, the incision was carried through the pubovaginal fascia into the fibrous sheath of the diverticulum until a good line of cleavage was found close to the junction of the mucosal lining with the fibrous sheath (Fig 4). The presence of the bag made the discovery and development of the line of cleavage quite simple so that all of the posterior and much of the lateral surfaces of the sac were easily exposed. The bag was then emptied and removed (Fig 5).

The vaginal fistulous tract and the anterior surface of the sac were freed from their adjacent structures and the urethral attachment of the neck of the diverticulum was carefully isolated. A purse string suture of No 00 chromic catgut was placed in the floor of the urethra around the neck of the diverticulum which was then cut across about 3 mm from the urethral orifice (Fig 6, a). In order to facilitate the inversion of the cufflike neck of the diverticulum into the lumen of the urethra and hold it into position while the purse string suture was tied, the following technique was introduced. The slightly bent, fenestrated end of a silver probe was introduced into the urethra and brought out through the lumen of the remaining cufflike end of the neck of the diverticulum. Four black silk traction sutures were spaced equally in the distal end of the cuff and their ends passed

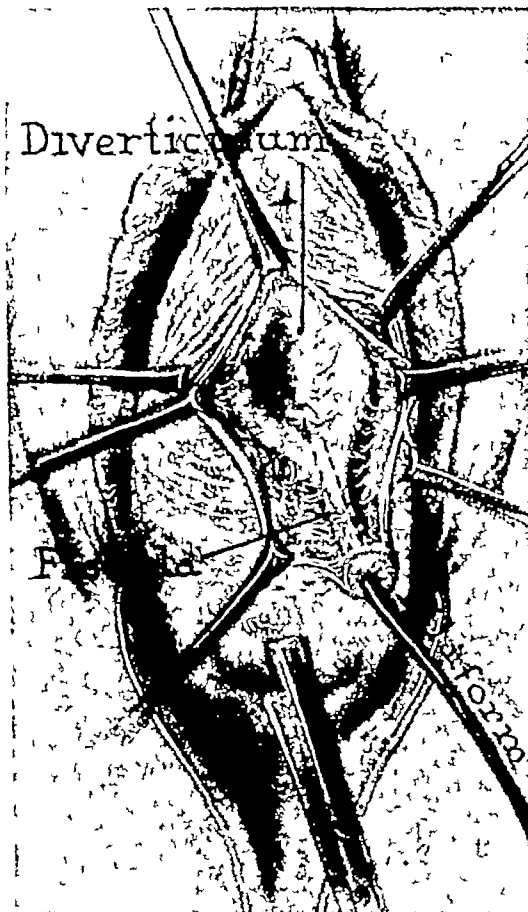


Fig 5—Distensible bag removed after sac and tract had been partially mobilized

through the fenestra of the probe (Fig 6, b). By withdrawing the probe, the free ends of the sutures were brought out through the urethra (Fig 6, c). Traction was applied to them, the purse string suture tightened and tied, and the traction sutures removed (Fig 7, a). This closure was reinforced by three interrupted No 00 chromic catgut sutures (Fig 7, b). The edges of the pubovaginal fascia were approximated by interrupted sutures of No 1 chromic catgut in such a manner that the line of sutures was well to the right of the area of urethral repair (Fig 7, c). There was considerable redundant vaginal mucosa, and this was removed from the left side so that when the edges were approximated by interrupted sutures of No 1 chromic catgut the repair line was considerably to

the left of the pubovaginal fascia approximation and even a little to the left of the urethral repair (Fig 8) A No 18 French Foley catheter was placed in the urethra for drainage

The gross specimen consisted of a thin walled, epithelial lined sac, one end of which was continuous with a fistulous tract of very small caliber that had at its end a cuff of vaginal mucosa. Unfortunately due to the exigencies of war, no sections were prepared for microscopic study

The patient was placed in prone position on a Brittord frame and sterile drainage maintained The catheter was diligently watched to make certain that drainage was constant and satisfactory The bladder was carefully irrigated twice a day with boric solu

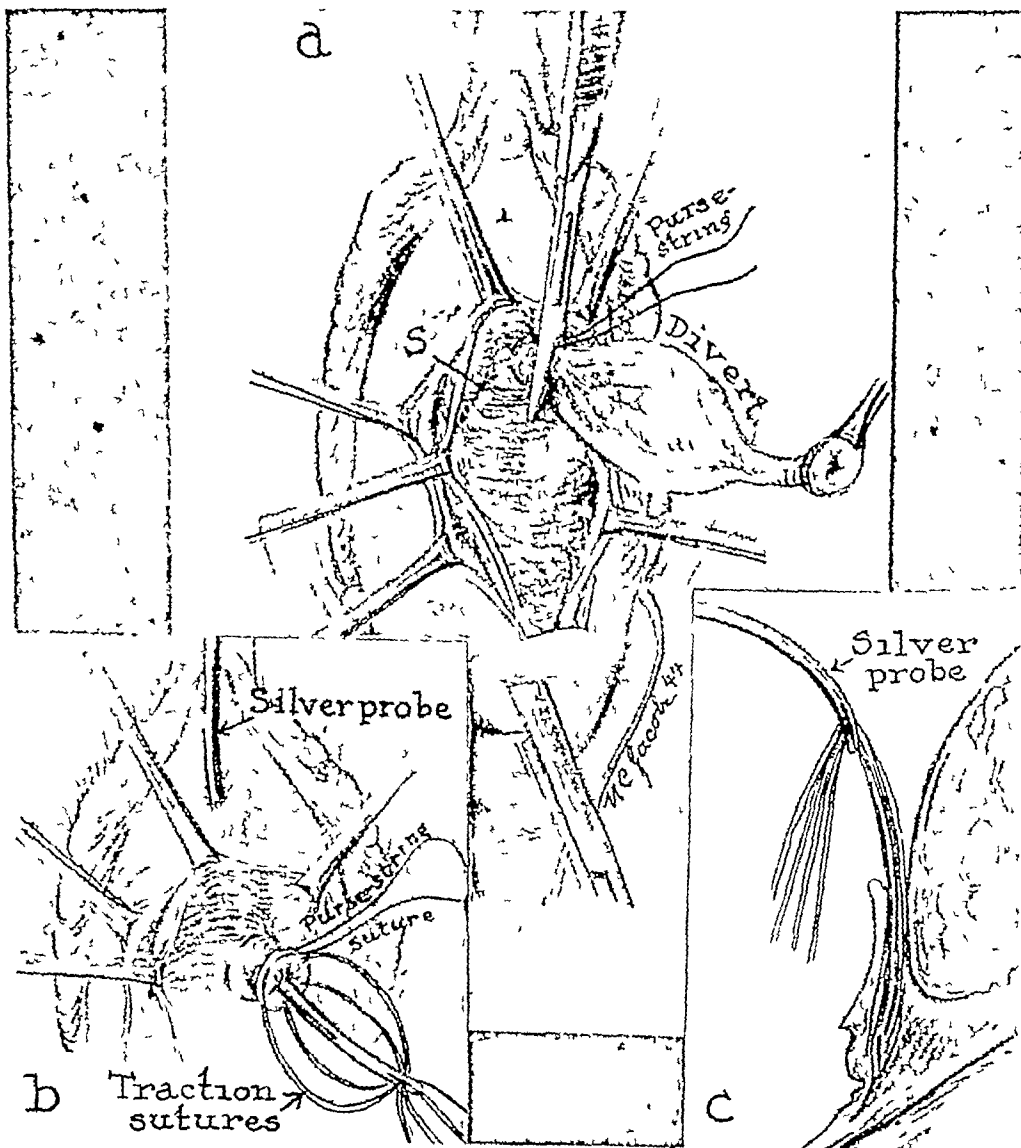


Fig 6—*a* Purse-string suture in position and neck of diverticulum about to be cut *b* traction sutures in fenestra of silver probe *c* probe withdrawn and neck of diverticulum being inverted into urethra

tion and once a day 15 c.c. of 1 per cent mercurochrome solution was instilled. The vaginal wound was thoroughly cleansed twice a day with irrigations of warm boric acid solution by means of an aseptic syringe. Following irrigations, the exposed portion of the vaginal wound was very carefully dried with sterile cotton pledgets. Sulfadiazine was given to control infection. She was placed on a low residue diet, and bowel movements were prevented for ten days by opium pills. At this time she was removed from the Bradford frame, placed on her back, and the catheter removed. When she was discharged nine days later, the wound was healed and urinary control was almost perfect. She was next seen two months later when control was perfect and the urine uninfected.

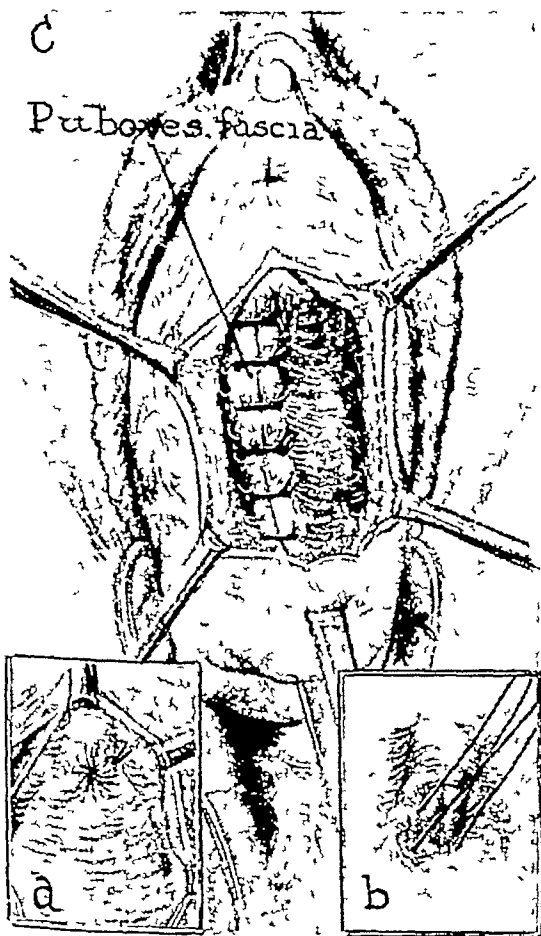


Fig 7

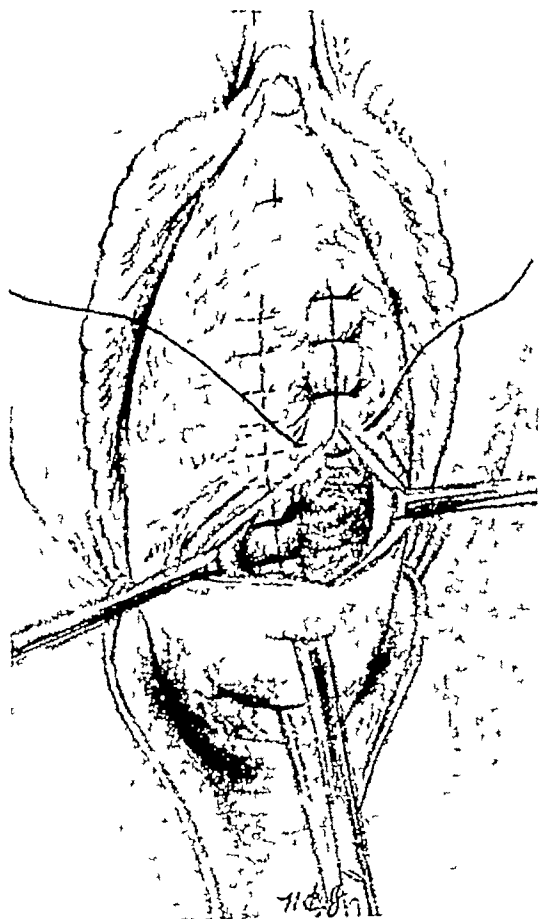


Fig 8

Fig 7—*a* Neck inverted and purse-string suture tied *b* reinforcement of purse-string suture *c* approximation of edges of pubovesical fascia to the right of urethral repair

Fig 8—The approximation of the edges of the vaginal mucosa considerably to the left of line of repair in pubovesical fascia and a little to the left of urethral repair

CASE 2 (S.M.H. No. 154396)—R.M., aged 30 years, was a single woman when first seen in the clinic in July, 1939. She stated that eighteen months previously she had caught a very severe cold which was complicated by marked frequency, urgency, and dysuria. Soon afterward, dribbling began, especially after voiding. A cystoscopic examination made elsewhere had revealed no reason for the difficulty, and various types of therapy had been tried without success.

Complete physical and neurologic examinations disclosed no explanation for the incontinence. On cystoscopic examination, no residual urine was found, the bladder capacity was 650 cc., and the tone was poor. There was fine trabeculation of the bladder wall, the trigone was a little atrophic, and the sphincter tone was not quite normal. Just outside the sphincter and a little to the right of the midline was the opening of a urethral diverticulum. In a corresponding position on the left side of the urethra were two small cellulæ suggesting that the patient might be developing multiple urethral diverticula. She had a negative syphilitic history and the Wassermann was negative. Cystometric studies indicated neurologic bladder changes of considerable degree. The urine was uninfected.

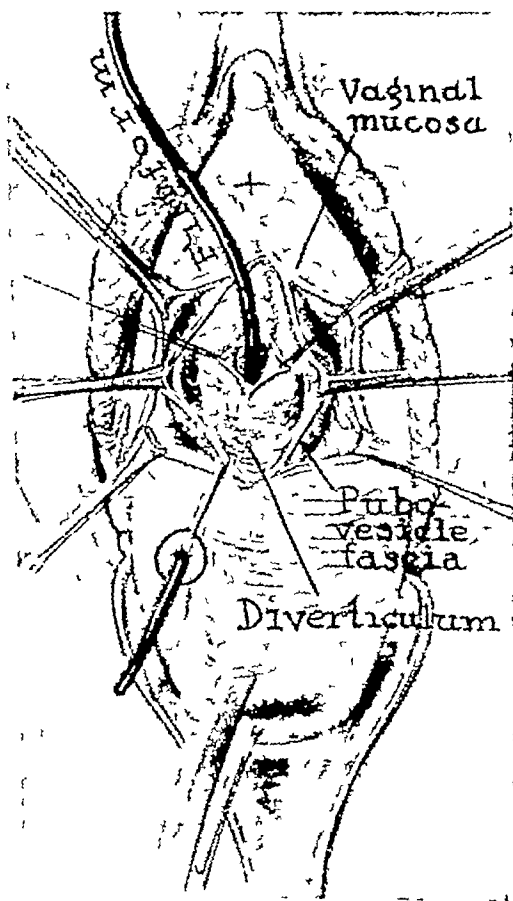


Fig 9

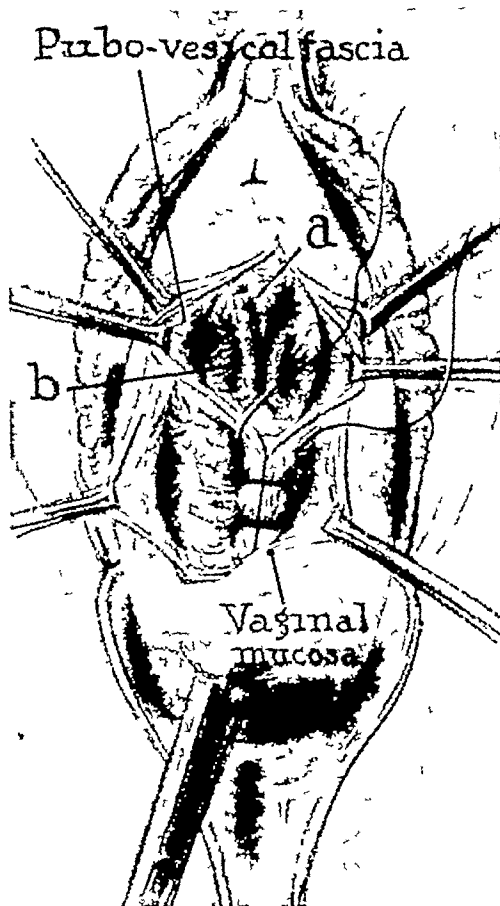


Fig 10

Fig 9—The thin epithelial lined wall of sac of diverticulum partially mobilized opened and filiform passed through fistulous tract to vagina.

Fig 10—*a* Closed reinforced inverted urethral orifice. *b* suture tightening vesical sphincter.

In the light of these findings, it seemed advisable to try conservative therapy before resorting to surgery. A sponge pessary was inserted and she was given urethral dilatations and instillations with 1 per cent silver nitrate. In addition she was taught to empty the diverticulum by digital pressure after voiding. She obtained considerable relief and married.

She was next seen in July, 1943, just five weeks after she had been operated upon elsewhere for incontinence. The bladder capacity was small and the vaginal mucosa was very irregular and markedly inflamed. It was evident that urine was seeping into the vagina from a fistulous tract connected with either the bladder or the urethra. She was

placed upon a regime to relieve the infection of the bladder and vagina with the hope that the fistulous tract would close, but it did not. On cystoscopic examination in February, 1944, it was found that the urethral diverticulum was still present and had increased somewhat in size. Furthermore, the deep end of the diverticulum was connected by a fistulous tract which drained into the anterior wall of the vagina at a point 3 cm. from the cervix and a little to the right of the midline. All efforts to pass a filiform through the vaginal opening of the tract into the sac of the diverticulum were unsuccessful. However, indigo carmine injected into the urethra appeared in the vagina. A catheter with attached distensible bag previously described was then passed into the diverticulum and filled with 15 cc. of water before causing any discomfort. It could be very easily felt under the trigone.

Because of the neurologic changes previously mentioned, a preliminary suprapubic cystostomy was performed. Under a regime of sterile drainage and vaginal douches with Dakin's solution the vaginal mucosa soon became quite normal. Since it was impossible to pass a filiform through the fistulous tract, the operative procedure in this case varied somewhat from that previously presented. The vaginal mucosa was incised over the distended diverticulum and its edges elevated. An incision similar in length and direction but a little more to the left was then made in the pubovaginal fascia and carried into the fibrous sheath of the diverticulum until a good line of cleavage was found close to the attachment of its mucosal lining. The sac consisting of a mucosal lining covered by a thin sheath of fibrous tissue was freed from its posterior and lateral attachments as much as possible. The water in the bag was released, the catheter removed, the sac opened, and a filiform passed through the opening in its end and into the vagina. The incision in the vaginal mucosa was then extended along the course of the filiform to the vaginal orifice of the fistulous tract around which a cuff incision was made (Fig. 9). The edges of the vaginal mucosa were elevated from the pubovaginal fascia which in turn was incised and its edges elevated. The fistulous tract and the diverticulum sac were removed and the wound repaired in the same manner as described in the previous case. In addition, the sphincter muscle was tightened by means of a No. 2 chromic catgut mattress suture which was placed before the edges of the pubovaginal fascia were approximated (Fig. 10, b).

The gross specimen consisted of the very thin walled, epithelial lined sac of the diverticulum and the attached fistulous tract with a cuff of vaginal mucosa at its end. Unfortunately, because of the exigencies of war no microscopic studies were made.

Except that no insulin was given, the postoperative care was essentially the same as in the previous case. The suprapubic tube was removed sixteen days after operation, and the patient was discharged two weeks later. When she was discharged, control was perfect.

DISCUSSION

While our knowledge of the symptoms of this disease is quite limited due to our meager personal observations and the scarcity of information on the subject in the literature, it seems safe to assume that for the most part they will be quite similar to those of the urethral diverticulum. In addition, we believe that in most of these cases, there will be urinary incontinence concomitant with vaginal irritation and dyspareunia. In two cases where the tumor was present for some time before drainage was established, the patients were quite sick, having chills, fever, nausea and vomiting, and low back pain. All of the patients had frequency, urgency, dysuria and urinary obstruction in varying degree.

The diagnosis of this condition is not difficult once the possibility of a ureterovaginal or vesicovaginal fistula has been ruled out and the presence of an urethral diverticulum proved. In spite of the fact that urinary drainage usually causes considerable inflammation and edema of the vaginal mucosa, a careful inspection of the vagina will usually disclose the vaginal orifice of the

fistulous tract connecting the sac of the diverticulum with the vagina. The appearance of indigo carmine in the vagina following the injection of the dye into the sac of the diverticulum offers convincing proof that a urethrodiverticulo-vaginal fistula is present. In our cases a vaginal examination after the introduction and distention of the rubber bag in the sac of the diverticulum gave us sufficient information concerning its location and size. Where further information is necessary it might readily be obtained by means of stereoscopic-roentgenographic studies following the injection of an opaque watery or oily x-ray medium into the sac of the diverticulum.

In both of our cases because of the size and location of the sac of the diverticulum and the presence of diabetes in one and neurologic bladder changes in the other it seemed especially advisable to remove the fistulous tract and sac of the diverticulum with as little trauma of the adjacent structures as possible. On several occasions, we had successfully treated a large bladder diverticulum by removing its mucosal lining and draining the collapsed fibrous sac according to the method described by Geraghty. It occurred to us that the presence of a distended rubber bag within the sac of the diverticulum might enable one to find more easily a good line of cleavage in the approximate neighborhood of the attachment of the mucosal lining with the fibrous sheath of the sac. If this were possible, the operation could be performed with greater facility and with no fear of injuring important near-by structures. In our two cases, at least, this proved to be true. Even in those cases where, due to the presence of infection, calculi, or tumor within the sac, the mucosal lining is lacking or if present so adherent to the fibrous sheath that a line of cleavage cannot be found, the distention of the sac by the bag should greatly aid in the dissection of the sac and its accompanying fistulous tract. Of course, it is conceivable that in a very occasional case the urethral orifice of the diverticulum will be found to be so small that even a small Dourmashkin catheter cannot be introduced into the sac. Under such circumstances it might be possible to introduce a filiform through the vaginal orifice of the fistulous tract leading to the sac as described in our first case. The tract could then be dilated to permit the introduction of the distensible bag or a Dourmashkin catheter and the operation completed according to the method described in our second case.

The successful repair of this condition as in the case of the vesicovaginal fistula depends in no small measure upon the preoperative preparation and most especially upon meticulous postoperative care. We have found that regardless of whether the bladder is drained by a cystostomy tube or a urethral catheter the wound heals better when the patient is placed in a prone position on a Bradford frame. Drainage is more direct, urine does not tend to puddle on the floor of the bladder, and where the urethral catheter is used for drainage there is less pressure against the repaired floor of the urethra. The liquid and low residue diets along with the prevention of bowel movements eliminate the danger of injury to the wound due to straining at stool, reduce the handling of the patient that otherwise would be necessary, and decrease the possibility of wound contamination. To correct any amino acid and vitamin defi-

ciencies that might result from the liquid and low residue diets, a supplementary amino acid and vitamin intake is indicated. It is absolutely essential that every precaution be observed to make certain that the drainage apparatus works satisfactorily at all times. In the care of the bladder and wound, we have found the routine outlined in Case 1 to be quite satisfactory.

CONCLUSIONS

1. The urethrodiverticulovaginal fistula is a relatively rare lesion.
2. An operative procedure used successfully in the repair of two of these cases has been presented.

REFERENCES

- Geraghty, J. T. South M. J. 15: 54-57, 1922.
Hickinbotham, J. Brit. M. J. 1: 613, 1982.
Parmenter, L. L. J. Urol. 45: 479-500, 1941.

OBSERVATIONS ON CHANGES IN STATES OF MENTAL DEPRESSION AND TENSION FOLLOWING SURGICAL SECTION OF CERTAIN FRONTAL LOBE PATHWAYS

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IT WOULD appear that a prefrontal lobotomy or the surgical division of the long white fiber association pathways running between the cortex of the frontal lobe and the structures posterior to them has a dramatic, marked, and usually beneficial effect on certain abnormal mental states. The abnormal mental states that appear to respond most favorably to such a surgical division of fibers are those in which mental depression and "tension" states predominate. A careful study of this problem has been made by Freeman and Watts and reported in their numerous publications. It has been speculated and argued that the relief from states of depression or tension results from a division of fibers running between the frontal cortex and the thalamus. Whether it is necessary to divide all of the other association pathways in the frontal lobe is still open to question. In order to gain further information on this point only certain tracts were divided and responses noted. The following case reports may lend some small increase in knowledge on this subject.

A unique opportunity came to hand in 1940. A male patient (H. H., Case 1) was referred by his physician because of an incapacitating mental depression. A prefrontal lobotomy as described by Freeman and Watts was carried out (Fig. 1). A desired and satisfactory result was obtained. The patient returned to work as an accountant in a gas and electric office. He was enough impressed by his own result that he secured the release of his sister from a state hospital (C. P., Case 2), she had been a patient there for some ten months, following a prolonged mental depression which the brother considered similar to his own. They proved to be as similar in temperament, habits, and general reaction to situations as any brother and sister could be. In the case of the sister a bilateral burr hole was made under local anesthesia in the temporal region. The arachnoid was opened on each side. White fibers were not touched. Following this the wound was closed. The patient was observed for a period of ten days. No change in the mental state was noted. At the end of that time a second operation was performed at which time the anterior half of the corpus callosum was exposed and divided. A cut was then made laterally into each frontal lobe white matter in order to divide the fibers anterior to the caudate nucleus (Fig. 2). This patient made a very satisfactory recovery, the details of which are set forth in the case report. No difference in the clinical result in the brother and the sister can be noticed. Both appear to be making very satisfactory progress some five years after the described procedure.

The question will naturally be raised concerning the effect of the division of the fibers in the corpus callosum on a state of mental depression and tension. In the course of a study of the spread of an epileptic attack, the corpus callosum has been divided in part or in its entirety in over a score of cases. It is believed that it may be said without any question that such a division of fibers has little if any effect upon mood, elation, mental depression, or tension.

In a third case in point a section of the anterior half of the corpus callosum was carried out plus a bilateral division of the white fibers anterior to the head of the caudate nucleus. This patient had become alcoholic and suicidal secondary to a chronically depressed mental state. The depression was promptly arrested for about four years, following which it has recurred.

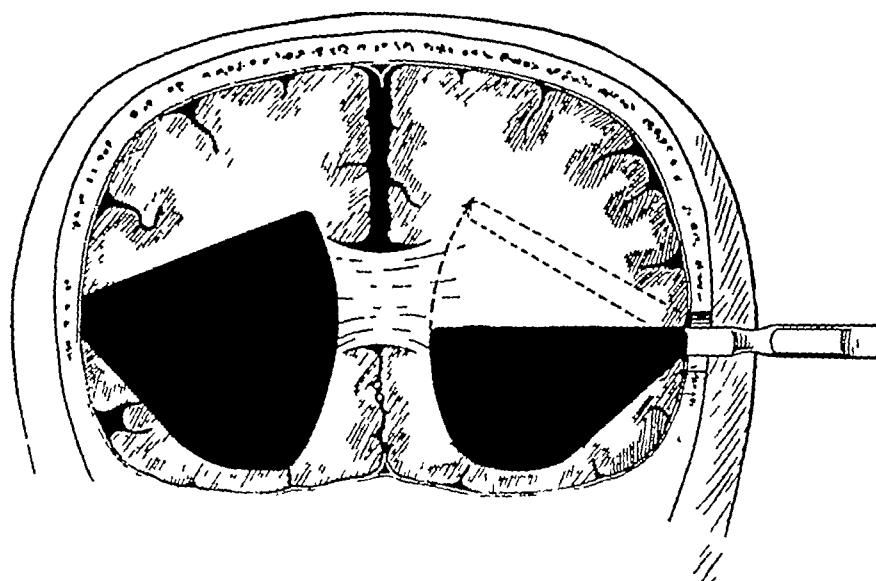


Fig 1—Area of division of white fibers in frontal lobes anterior to ventricles (After Freeman and Watts 1940)

In a fourth case a unilateral prefrontal lobotomy using the Watts technique was carried out with equivocal result. The anterior half of the corpus callosum was then divided. Technical difficulties prevented section of white fibers anterior to the caudate nuclei. No appreciable change in the mental state was noted.

CASE REPORTS

CASE 1 (No 172324) —H. H., aged 40 years, was admitted to Strong Memorial Hospital, Dec 2, 1940.

At the time of admission this office worker stated that he had always been "nervous, high strung, and depressed." He gave a long and detailed account of various emotional states in which he had been and had them listed on paper in chronological order. Fear had been the core and subject of the theme for the outstanding complaints. At the age of 6 his mother fell downstairs. He became so frightened that he was "frozen with fear" and was actually unable to move for a time. While a student in the second grade he was reprimanded for some trivial happening and became so terrified that he lost control of the bladder. Since the age of 15 he had had difficulty in sleeping. He was married at the age of 24 and is the father of

two children. The marriage did not prove to be a compatible one. His wife was evidently as unstable emotionally as he, and there had been constant argument and bickering over the period of sixteen years of married life. The wife was confined to a state hospital in 1945 because of a serious mental depression but improved following the use of insulin shock. The patient continued to work for a gas and electric company as an auditor for a period of some eighteen years prior to entry. There were many lapses and much loss of time because of

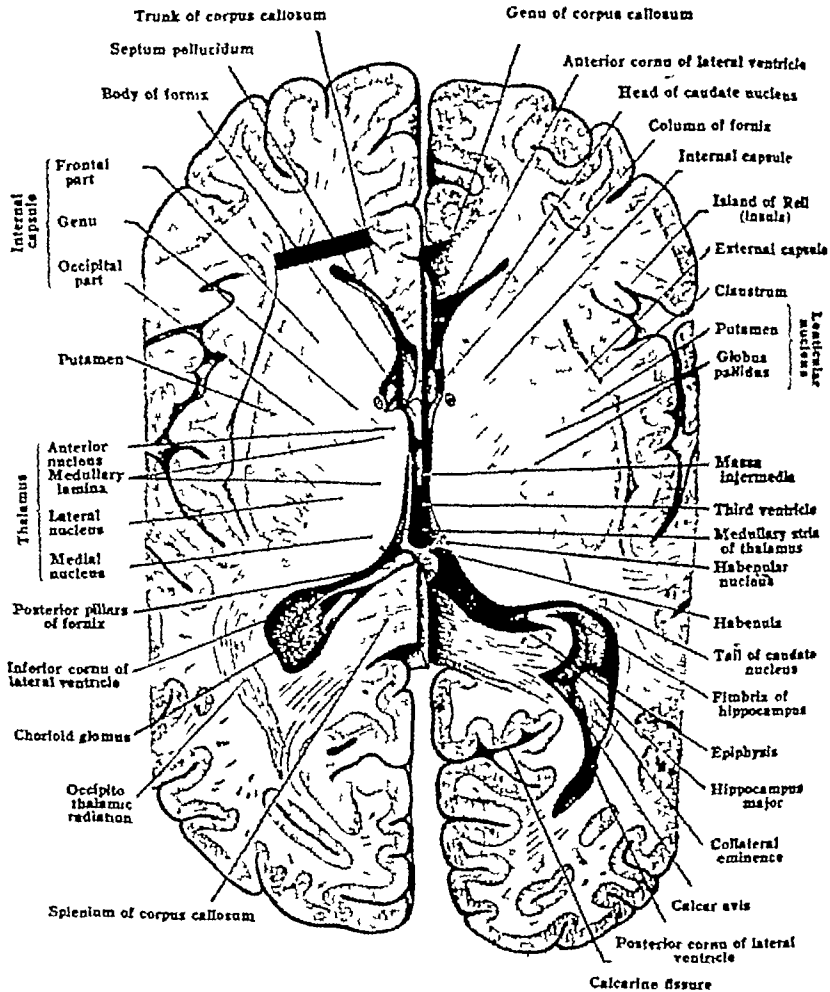


Fig 2—Heavy black line anterior to ventricle represents plane and site of bilateral cut in white fibers. Depth of cut is one inch. (After Morris *Human Anatomy*)

“feeling depressed, crying spells, and inability to go on with it.” Some four months prior to entry he was admitted to a state hospital where insulin shock therapy was tried without notable improvement. Since then he had seen many physicians for the complaints and had about all of the psychotherapy that could be offered. Just prior to admission, he had been in a sanatorium where he had been treated by means of sedatives and baths. In spite of these, he continued to be markedly depressed, had prolonged crying spells, interspersed with periods of great fear and anxiety over the outcome of his own illness, what would happen to his family, the general state of the community, and the nation. From a practical point of view, he appeared to be totally incapacitated for any useful work or for living in the community.

The neurologic examination was entirely normal. The general physical examination was normal. All laboratory data were normal, including an electroencephalogram. The opinion of the department of psychiatry was that the patient was suffering from a mood disturbance depressive state.

On Dec 7, 1940, a bilateral prefrontal lobotomy was carried out under local anesthesia. The technique described by Watts was used. After the last incision in white matter had been made, the patient became quite markedly confused. He did not develop symptoms referable to the autonomic nervous system such as loss of sphincter control or marked sweating. He remained confused to a mild degree for approximately one week to ten days. Following that, he became clear mentally and was discharged on the fourteenth postoperative day. At the time of discharge, he made the comment that "I have left all of my troubles in the operating room."

In the intervening five years the patient has continued to work at his job as an accountant. He has worked for two separate companies. There have been periods when he has been irritable, when he has been under a moderate amount of tension, and has required the use of phenobarbital for short periods of time. It would appear that he had adequate grounds for the irritations and complaints in that there was a most difficult family situation. The patient's wife became more and more depressed and as previously stated was finally admitted to a state hospital with a diagnosis of schizophrenia. Following her improvement, he also became more placid.

In summary, it would appear that this patient has made a near complete recovery from the complaints of fear and mental depression and an excellent adjustment to his problems and surroundings. On the whole, he appears to be reasonably calm and deliberate, and to be able to reason and plan and calculate, in a normal manner. His periods of depression are short lived and relatively minor. The patient himself appears to be much satisfied with the result.

CASE 2 (No 175483) —C P, aged 46 years, sister of H H (Case 1), was admitted on March 2, 1941, with a complaint of "worry and fear that I can't get anything done."

This patient had been worried and fearful all of her life over one thing or another. Like her brother, fear had been the central theme of the complaints. In childhood it was inability to get along in school although she did moderately well. Later on, it was worry over her father's finances, although they were in good condition. After marriage, it was regarding the future of her son and whether she was doing the right thing in bringing him up in order that he might avoid her difficulties. She was particularly worried about whether he would be good in arithmetic because she was not good at it and felt that she could not help her husband with his business properly because of it.

About one and one half years prior to entry, she began to worry a great deal about the household duties and her husband's business. She would sit for hours holding her hands and neglect the housework. Her husband developed minor difficulties with his business and sold a part of it. She became convinced that she could no longer do the bookkeeping although he affirmed she was doing it quite well. At about that time she developed ideas of persecution, thinking that people were conspiring to ruin their business and to take her husband's affections away from her. At about that time, that is, May, 1940, she attempted to commit suicide by drinking rubbing alcohol. Following this the patient was committed to a state hospital in May, 1940.

During the patient's stay in the state hospital she was markedly depressed. She sat by herself a great deal of the time, wringing her hands and pulling her hair. She was suspicious that the food was being poisoned. She felt that she was being discriminated against, and that her family had lost all interest in her.

The physical examination showed a thin, lean, wiry woman who had good rapport with her surroundings. She would sit by herself a good deal of the time picking at her clothing. No actual crying spells were noted but the patient had a very unhappy look and never smiled. She did not seem to have any sense of humor. She was very discontented with her lot and with the treatment. She was slightly irritable at times and was doubtful of the advisability of coming to the hospital at all as her brother had advised.

Her stream of thought was unusually active for a patient with a depression. Her story was told at great length, at great detail, and in a logical chronological order. Her conversation was relevant and coherent. Responses to questions were prompt, complete, and to the point without rambling. The general physical examination was normal. The neurologic examination was normal. All laboratory data were within normal limits, including an electroencephalogram.

The psychiatric opinion was that the patient was suffering from an agitated depression (involuntional melancholia).

On March 10, 1941, a burr hole was made in each temporal region over the coronal sutures. This was carried out under novocain anesthesia until the dura was exposed. At that time the patient became so restless and unmanageable that a general anesthesia had to be resorted to. The arachnoid was opened on each side. The incisions in the brain were not made. At that point the wounds were closed.

During the following ten days the patient appeared unchanged in behavior. There was no change in physical examination.

On March 19, 1941, a right frontoparietal bone flap was turned down carrying the flap across the longitudinal sinus over the left hemisphere for approximately one inch. The posterior limb of the incision in the bone was approximately one inch posterior to the coronal suture. The anterior portion of the corpus callosum was exposed and divided. The incision in the corpus callosum extended from the subcallosal gyrus backward to include the anterior half of the corpus callosum. The anterior commissure was divided. A good exposure of the infundibulum and optic chiasm and lamina terminalis was had. The right limb of the fornix was divided. An incision in the white matter anterior to the caudate nucleus was made bilaterally. The area of the cut was estimated at 1 to 1 1/4 inches square. Following operation the patient became markedly confused for about ten days. She exhibited, for a few days, periods of sham rage which had been seen in other patients who had had frontal lobe white fiber sections. The slightest irritation of the skin about the incision or about the body surface led to complaints of great pain, screaming, and comments of an irrelevant nature, such as, "you're draining the blood out of me," "don't let that blood touch me anywhere," "you're trying to kill me."

After about ten days of this behavior she became oriented, quiet, agreeable, and much more cheerful. She was discharged from the hospital six weeks after operation.

The patient was seen three and one half months after operation, at which time she was doing all of her own work. She was able to look after a garden, do her own marketing, and she was no longer worried by the minor events about the house. She had gained up approximately ten pounds in weight, and looked extremely well.

When seen six months after operation she had improved still more. If anything, she was a little overactive and aggressive rather than being on the depressed side. Her memory appeared to be intact. Her ability to reason, calculate, and plan was normal. Insight into the situation at home was normal.

When interviewed on Jan. 9, 1946, nearly five years after operation, she appeared to be in the best of health. She was doing all of her own work and had taken a leading part in various church activities. She reads magazines pertaining to gardening and assists with the bookkeeping in her husband's business. She states that she is no longer depressed. She is a little short tempered at times but no more than she has been for years. Her husband states that "she is the girl I married years ago." The patient and her husband are very much satisfied with the turn of events and feels that she is back to normal.

CASE 3 (No 174632)—B. B., aged 44 years, was admitted to the hospital March 4, 1942. The chief complaints were (1) periodic recurring bouts of mental depression and (2) recurring bouts of alcoholism.

This patient evidently was well mentally until about 1934, at which time he stated that he had a "nervous breakdown." This was manifested by periods of brooding, melancholia, mental depression, and ideas of persecution. He believed that this nervous breakdown was precipitated by a conflict at home, when his wife left him to live with another man. Whereas

he was formerly satisfied with an occasional drink of beer or ale, he began to drink rather heavily of hard liquor. The drinking bouts would last from a few days to three months. At times he developed delirium tremens and evidently a peripheral neuritis secondary to deficiency in vitamins. After the alcohol bouts the patient was again able to carry on with his work as a stenciler for a matter of two to three months before the same process would again occur because of mental depression and ideas of persecution. Because of these complaints, plus an attempt at suicide, he was committed to a state hospital for a period of some sixteen months. He had several minor jail commitments because of difficulties while intoxicated. The transfer diagnosis from a state hospital was that of "psychopathic personality with a reactive depression."

The physical examination was unremarkable. In regard to the mental status, the patient was pleasant and cooperative at the times seen. Psychomotor activity was within normal limits. He was in good rapport with his surroundings. He was slightly nervous and occasionally showed minor tremors of the hand, not of a preoccupation type. There were no special postures, mannerisms, or attitudes.

Stream of talk was spontaneous and apt to be a little juvenile at times. However, it was relevant and coherent. Answers to questions were prompt, adequate, and to the point. There was no attempt at rhyming or punning, no slurring of the speech or aphasia.

His mood was pleasant and cheerful at the time seen, without being too euphoric. He smiled appropriately and there did not appear to be any flattening of the affect.

At other times when the patient was observed alone, he sat by the window, held his head, pulled his hair, wrung his hands, and when questioned as to the reason for this was likely to make a statement such as, "Why can't I feel like I used to?" "Why do I have to get into so much trouble?" "I wish I was over this alcoholism."

On March 6, 1941, the corpus callosum was divided down to and into the subcallosal gyrus from its mid point forward. The right limb of the fornix was also divided. Following this an incision was made into the white fibers anterior to the head of each caudate nucleus. The area of division of white fibers on each side was estimated at approximately one square inch.

Following this procedure the patient became moderately confused for a period of one week to ten days. He was discharged from the hospital on the fifteenth postoperative day.

This patient has been seen on a number of occasions during the ensuing five years. He has been gainfully employed during most of this time, usually doing some light form of laboring work, such as washing cars. During this period he has remained in good spirits, he has not had any evidence of the former mental depression until the fall of 1945. At that time a series of events proved "just too much for me." "My son was in an army hospital for eighteen months and didn't write to me. He came home to get married and didn't see me." "I'm all alone except for my old mother." He then went on a prolonged alcoholic spree, at the end of which he became embroiled in financial difficulties. He wrote checks on a bank for which he did not have funds and was taken into custody.

In summary, this patient appeared to have been largely relieved of the chronic mental depression suffered for a period of years prior to operation. He has had one relapse and is now under observation again.

CASE 4 (No 171713)—C S, aged 50 years, was admitted Nov 6, 1940, because of "nervousness."

At the time of admission it was difficult to state where the illness began. According to her husband she became "very nervous" some twenty years ago, at which time she was having a series of abortions, probably self induced. This complaint extended over a period of some four years. Since then she became increasingly hypochondriacal and depressed. "I got a headache. I can't sneeze because it hurts my head, so I can't get rid of my headache." The symptoms seemingly covered every conceivable system in the repertoire of human ills. When getting her breath from long and furious talking she would sigh then swallow air and belch gas. She ascribed the gastric complaints to the fact that she had the gall bladder and appendix removed because of abdominal complaints.

The physical examination showed a short, stout woman who appeared very depressed and sad. She never smiled or appeared to enjoy anything. She was constantly worried over "my poor children, my head, my heart, my feet, my back." At times she induced skin and nasal mucous membrane bleeding by rubbing or pinching with the fingernails in order to "get to see a doctor and tell him my troubles."

At times she indulged in brief crying spells. When with her husband she was apt to be argumentative. She said that she had not slept in three months. He told of her having gone to sleep each night on the davenport in the living room for two or three hours and having to be awakened to go to bed. She maintained that she was only pretending to sleep to see if he cared whether she slept or not. Such arguments were unending. Her husband stated that she kept a cupboard full of medicines and was constantly taking something.

Laboratory data were normal.

On Dec 8, 1941, a left prefrontal lobotomy (Watts technique) was carried out.

No essential change in her mental state resulted.

On Dec 27, 1941, the anterior half of the corpus callosum was divided. A division of the right prefrontal white fibers anterior to the caudate nucleus had been planned. However, technical difficulties made this seem inadvisable at the time.

The patient has been seen on numerous occasions since that date. For a time she appeared slightly improved. She smiled and joked occasionally and had quite a sense of humor when in the right mood. When having a dressing done she would cry and moan and wring her hands and a moment later smile and appear to be enjoying having put on an act. In the four years following operation she has seemed on the whole to be a little less depressed but has not ceased to complain of various symptoms. She openly admits going to outpatient departments every two or three weeks in order to get someone to listen to her. She has continued to do all of her housework and occasionally visits the neighbors, something she had not done in years.

In summary, there has been an improvement in mood without any diminution in the quantity or quality of subjective complaints.

DISCUSSION

A small amount of information has been presented to support the belief that the bilateral division of the white fiber pathways between the basal ganglion and the frontal lobe cortex is sufficient to secure relief from states of mental depression and tension. Section of more white fibers may be unnecessary. From a practical point of view the prefrontal lobotomy as described by Watts is a desired procedure. Division of white fibers only running between basal ganglia and frontal poles via the corpus callosum route is a very major procedure that should not be undertaken without full awareness of the technical difficulties and hazards.

Division of white association fibers in the corpus callosum per se is not followed by change in states of mental depression or tension.

SHOULD WE STANDARDIZE THE RECONSTRUCTION AFTER PANCREATICODUODENECTOMY?

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DURING the last decade following the pioneer work of Whipple⁴⁰ and Brunschwig¹ the operation for resection of the head of the pancreas and duodenum has emerged from "well nigh insuperable"²⁵ mechanical difficulties to become an accepted surgical procedure. In this interval practically every surgeon who has done the operation has modified the technique so that a review of the methods used makes one dizzy to follow the loops and turns used to reconstitute the patient's anatomy. Twenty-nine different ways of doing the operation have been described, yet there are only a few fundamental principles involved. It is felt that the emphasis should be shifted from the technique of the reconstruction to a study of the problems involved in restoring pancreatic function, to remove more adequately the regional lymph glands and finally to the collection and analysis of sufficient cases to evaluate the effectiveness of the operation in curing cancer.

My purpose is to urge a standardized technique of reconstruction. To this end the evolution of the technical principles is explained and some problems of management discussed, but it would only be confusing to describe the contribution of all authors in this field. The reader is referred to the references for this.

THE RECONSTRUCTION

The principles underlying the restoration of the continuity of the digestive tract are considered to be

- (1) The use of a retrocolic, end-to-side gastrojejunostomy
- (2) The implantation of the common bile duct into the intestine
- (3) The reconnection of the pancreas to the intestine
- (4) The diversion of the gastrointestinal contents away from the liver and pancreas by antiperistalsis

The chronology of development of these principles is as follows

In 1938 Whipple reported⁴¹ the use of the Roux Y anastomosis of the intestine to the gall bladder (Fig 1). The use of this antiperistaltic loop between the gastrointestinal and biliary tract prevents reflux of gastric contents into the bile ducts. The force of antiperistalsis was well demonstrated by Mall.²³ Ordinarily, it is sufficient to prevent the devastating effects of cholangitis which may follow loss of the sphincter of Oddi. Postoperative x-ray studies have shown

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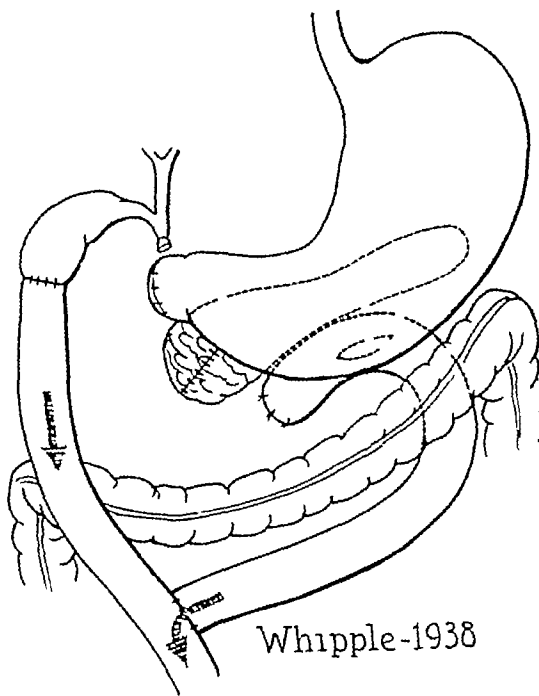
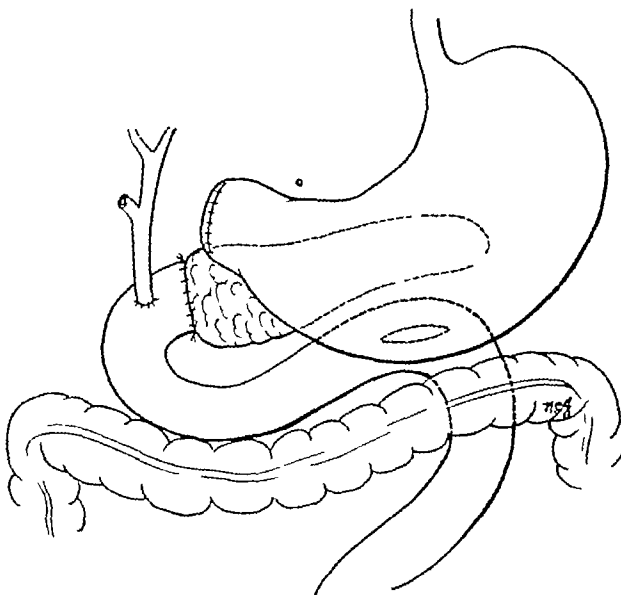


Fig 1.—The Roux Y principle of draining the biliary tract was used by Whipple in 1938. It is important to avoid reflux of gastrointestinal contents into the bile ducts and this is best done by making use of antiperistalsis.



Hunt 1941

Fig 2.—The operation reported by Hunt foreshadowed later developments. His patient had the gall bladder removed and the entire duodenum involved so the common duct and pancreas were anastomosed to the jejunum.

barium to reflux three or four inches and then be carried down away from the bile ducts so it is probable that the antiperistaltic loop should be at least eight inches long for adequate protection. There is grave doubt if an enteroanastomosis between two sides of a jejunal loop will short-circuit all of the intestinal contents from the biliary tract. Cases reported by Cole⁹ would indicate it does not.

Hunt, in 1941,¹⁹ described an operation (Fig 2) that foreshadowed later developments. His patient had the gall bladder removed so the common duct was implanted into the intestine. Orr²⁰ in the same year, and for the same reason, also used the common duct. It is to be noted that this was dictated by necessity, as was also the removal of the entire duodenum in Hunt's case, for it was involved in the disease. He brought the jejunum up to anastomose it end to end with the pancreatic stump.

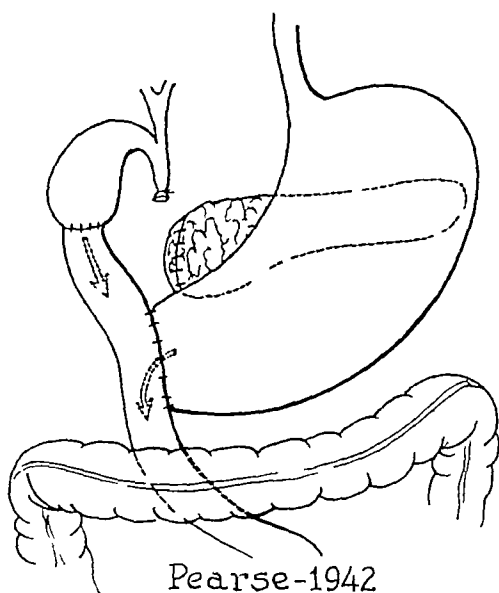


Fig 3—Because of the danger of necrosis of the duodenal stump it was excised and the jejunum brought up to unite with the gall bladder. A retrocolic end-to-side gastrojejunostomy completed the repair. At first six inches of jejunum were placed between the biliary tract and stomach. Later this was lengthened to eight inches when postoperative barium studies showed reflux of as much as four inches. Dennis suggested a similar anastomosis using a longer loop.

In 1941, because of a fatality from necrosis of the duodenal stump,³¹ and because of Ziegler's⁴⁷ dissections of the blood supply, I removed the entire duodenum and used the jejunum to anastomose to the biliary tract and stomach (Fig 3). This simplified the anastomosis, yet retained the antiperistaltic biliary anastomosis, so the procedure was reported.³⁰ As was customary at that time, the intestine was anastomosed to the gall bladder and the pancreas was closed. Dennis¹³ reported a somewhat similar procedure using a long antiperistaltic loop.

As experience accumulated it became apparent that the anastomosis to the gall bladder was unsatisfactory for two reasons. First, obstruction or angulation of the cystic duct might prevent free drainage of bile. Second, the ligated end of the common duct might open to form a biliary fistula, often with a fatal

result This led Whipple⁴³ in 1942 to implant the common duct into the end of the jejunum Subsequently, his results and those of others have proved that this adds to the safety of the operation

The final step was the anastomosis of the pancreatic duct into the jejunum (Fig 4) by Whipple⁴³ and by Cattell⁵ in 1943 This diminished the incidence of postoperative pancreatic fistulas Whether or not it restores pancreatic function is still not settled Brunschwig² felt that even with the duct implanted into the intestine the pancreas becomes fibrous and ceases to function More

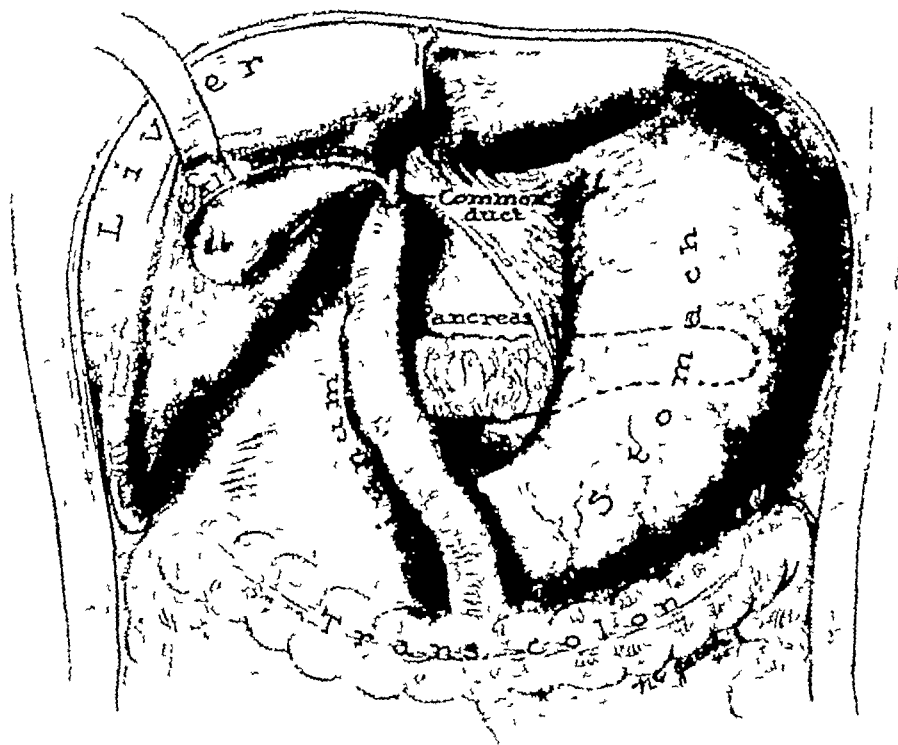


Fig 4—To avoid biliary and pancreatic fistulas the common duct was united end to end and the pancreatic duct anastomosed end to side with the jejunum (Whipple 1943) The position of the duct and pancreas may be reversed if it is desired to implant the stump of the pancreas into the end of the jejunum This fulfills all the requirements of the reconstruction

information is needed on the ultimate fate of the transplanted pancreas in human beings, for it is possible that data obtained from experiments in dogs may not be applicable Two methods have been used in attempting to restore the pancreatic secretion, (1) by implanting the cut end of the pancreas into the intestine, or (2) by anastomosing the pancreatic duct to the bowel The implantation of the pancreas was studied by Coffey⁶ in 1909 and has been used by several surgeons Child⁷ illustrated the present technique The experiments of Person and Glenn³² showed continuation of pancreatic function in animals with transplantation of the pancreas into the stomach

The anastomosis of the pancreatic duct has been done by Poth³⁵ with a silver cannula, by Ziminger⁴⁶ with a vitallium tube, by Cattell with a necrosing suture of the ligated duct, and by Whipple⁴⁷ and others with a small rubber tube or catheter (Fig 5). The cut surface of the pancreas is closed with interrupted sutures, leaving the duct protruding through this suture line. After anastomosis of the duct the pancreas is sutured to the intestine giving a broad area of attachment for support.

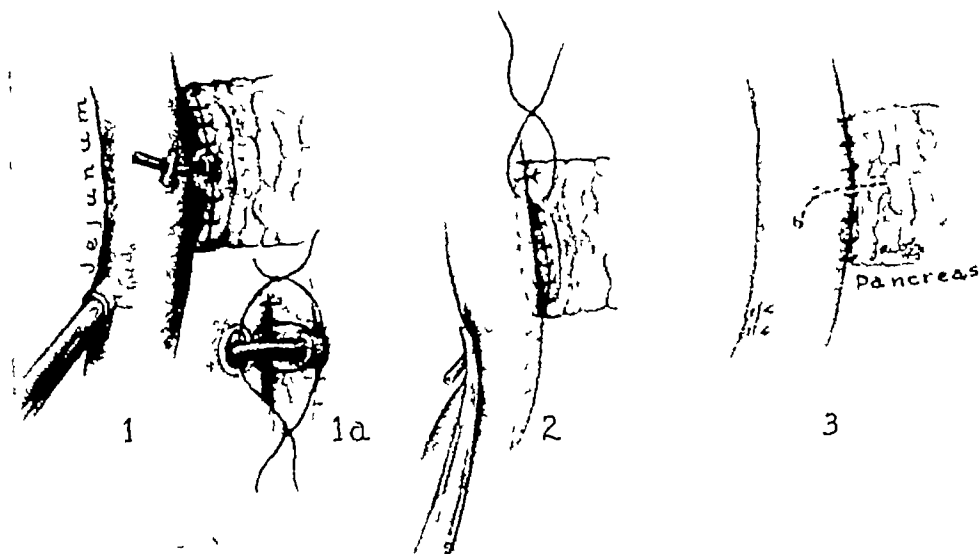


Fig 5—The anastomosis of the pancreatic duct using a small rubber tube. (1) The end of the pancreas is closed leaving the duct protruding. The posterior capsule of the pancreas is sutured to the jejunum and a rubber tube is sutured into the duct. A clamp is used to pull the tube into the bowel. (1a) Sutures are placed to unite the tube to the jejunal wall. They are tied when the tube is pulled tight. (2) Tension is maintained on the tube while the anterior capsule of the pancreas is sutured. (3) The final anastomosis. The broad attachment of the pancreas to the jejunum gives firm support to the anastomosis of the duct.

At present there is not enough evidence to judge which is the best method. The only proved benefit from reattaching the pancreas is the elimination of pancreatic fistulas. How long and how well the pancreas functions is yet to be determined.

SUMMARY

It appears desirable to standardize the technique of reconstruction after resecting the duodenum and head of the pancreas. This would avoid confusion, facilitate the operation, and eliminate technical variables in the analysis of the end results. The evolution of the technical developments is discussed to illustrate the fundamental principles involved. Most of these principles were established by Whipple, therefore it would appear fitting to call this the Whipple operation as an acknowledgment of his contributions.

REFERENCES

1. Brunschwig, A. Resection of Head of Pancreas and Duodenum for Carcinoma—Pancreaticoduodenectomy, *Surg, Gynec & Obst* 65: 681, 1937.
2. Brunschwig, A. One Stage Pancreaticoduodenectomy, *Surg, Gynec & Obst* 77: 581, 1943.

- 3 Brunschwig, A, and Allen, J G Occlusion of the External Pancreatic Secretion in Man, *Proc Soc Exper Biol & Med* 52 43, 1943
- 4 Brunschwig, A Survival of Rhesus Monkey Four Years After Excision of Pancreas With Occlusion of External Pancreatic Secretion, *SURGERY* 16 416, 1944
- 5 Cattell, R B Resection of the Pancreas, *S Clin North America* 23 753, 1943
- 6 Cattell, R B Pancreatoduodenal Resection, *New England J Med* 232 521, 1945
- 7 Child, C G III Pancreaticojejunostomy and Other Problems Associated With the Surgical Management of Carcinoma Involving the Head of the Pancreas, *Ann Surg* 119 845, 1944
- 8 Coffey, R C Pancreato Enterostomy and Pancreatectomy, *Ann Surg* 150 1238, 1909
- 9 Cole, W H, Ireneus, C, Jr, and Reynolds, J T The Use of Vitallium Tubes in Strictures and Absence of the Common Bile Ducts, *Ann Surg* 122 490, 1945
- 10 Cole, W H, and Reynolds, J T Resection of the Duodenum and Head of the Pancreas for Primary Carcinoma of the Head of the Pancreas and Ampulla of Vater, *SURGERY* 18 133, 1945
- 11 Coller, F A, and Winfield, J M, Jr Evaluation of Palliative Operation, for Cancer of the Pancreas, *Am J Surg* 25 64, 1934
- 12 Dennis, C, and Varco, R Neoplastic Biliary Obstruction, *Surgery* In press
- 13 Dennis, C A Modified Whipple Operation for Carcinoma of the Head of the Pancreas, *SURGERY* 12 201, 1942
- 14 Dragstedt, L R Some Physiologic Problems in Surgery of the Pancreas, *Ann Surg* 118 576, 1943
- 15 Gordon Taylor, G Radical Surgery of Cancer of Lower End of the Common Bile Duct and Pancreas, *Brit J Med* 2 119, 1942
- 16 Gray, H. K., and Sharpe, W S Surgical Treatment of Carcinoma of the Papilla of Vater, *SURGERY* 14 831, 1943
- 17 Harvey, S C, and Oughterson, A W The Surgery of Carcinoma of the Pancreas and Ampullary Region, *Ann Surg* 115 1066, 1942
- 18 Horsley, J S Resection of the Duodenum for Tumor of the Ampulla of Vater, *Ann Surg* 113 802, 1941
- 19 Hunt, V C Surgical Management of Carcinoma of the Ampulla of Vater and of the Perampullary Portion of the Duodenum, *Ann Surg* 114 570, 1941
- 20 Judd, E S, and Hoerner, M T Surgical Treatment of Carcinoma of the Head of the Pancreas and of the Ampulla of Vater, *Arch Surg* 31 937, 1935
- 21 Labey, F H, and MacKinnon, D C Carcinoma of the Pancreas, *S Clin North America* 18 695, 1938
- 22 Maingot, R Resection of Head of Pancreas and Duodenum for Carcinoma, *Lancet* 2 798, 1941
- 23 Mall, F Reversal of Intestine, *Johns Hopkins Hosp Rep* 1 93, 1896
- 24 Moreland, R B, and Freeman, B S Two stage Resection of Carcinoma of the Ampulla of Vater, *SURGERY* 9 712, 1941
- 25 Moynihan, B Abdominal Operations, vol 2, Philadelphia, 1914, W B Saunders Company, p 426
- 26 Orr, T G Discussion of paper by Hunt, V C, *Ann. Surg* 114 602, 1941
- 27 Orr, T G Resection of Duodenum and Head of Pancreas for Carcinoma of the Ampulla, *Surg, Gynec & Obst* 73 240, 1941
- 28 Orr, T G, and Walker, G A Pancreaticoduodenectomy for Primary Carcinoma of the Duodenum, *Surg, Gynec & Obst* 80 149, 1945
- 29 Orr, T G Pancreaticoduodenectomy for Carcinoma of the Ampulla and Ampullary Region, *SURGERY* 18 144, 1945
- 30 Pearse, H E A Simplified Anastomosis for Resection of the Duodenum and Head of the Pancreas, *Surg, Gynec and Obst* 75 333, 1942
- 31 Pearse, H E Discussion of paper by Harvey, S C, and Oughterson, A W, *Ann Surg* 115 1090, 1942
- 32 Person, E C, and Glenn, F Pancreaticogastrostomy Experimental Transplantation of the Pancreas Into the Stomach, *Arch Surg* 39 530, 1939
- 33 Phillips, J R Excision of the Duodenum and Head of the Pancreas for Carcinoma of the Ampulla, *Am J Surg* 60 137, 1943
- 34 Pickrell, K. L., and Blalock, A. The Surgical Treatment of Carcinoma of the Common Bile Duct, *SURGERY* 15 923, 1944
- 35 Poth, E J The Implantation of the Pancreatic Duct Into the Gastrointestinal Tract, *SURGERY* 15 693, 1944
- 36 Sallick, M A, and Garlock, J H Obstructive Jaundice Due to Carcinoma of the Pancreas The Choice of Operative Procedure, *Ann Surg* 115 25, 1942
- 37 Sauv  , L Des pancr  ectomies, *Rev de chir, Paris* 37 335, 1908
- 38 Trimble, I R, Parsons, J W, and Sherman, C P A One Stage Operation for the Cure of Carcinoma of the Ampulla of Vater and of the Head of the Pancreas, *Surg, Gynec & Obst.* 73 711, 1941

- 39 Watson, K Carcinoma of Ampulla of Vater, Successful Radical Resection, Brit J Surg 31 368, 1944
- 40 Whipple, A O, Parsons, W B, and Mullins, C R Treatment of Carcinoma of the Ampulla of Vater, Ann Surg 102 763, 1935
- 41 Whipple, A O Surgical Treatment of Carcinoma of the Ampullary Region and Head of the Pancreas, Am J Surg 40 260, 1938
- 42 Whipple, A O The Rationale of Radical Surgery for Cancer of the Pancreas and Ampullary Region, Ann Surg 114 612, 1941
- 43 Whipple, A O, in discussion of paper by Harvey, S C, and Oughterson, A W Ann Surg 115 1085, 1942
- 44 Whipple, A O Present Day Surgery of the Pancreas, New England J Med 226 515, 1942
- 45 Whipple, A O Discussion of paper by Dragstedt L R Some Physiologic Problems in Surgery of the Pancreas Ann Surg 118 589, 1943
- 46 Whipple, A O Pancreaticoduodenectomy for Islet Carcinoma A Five Year Follow Up, Ann Surg 121 847, 1945
- 47 Ziegler, H R Excision of the Head of the Pancreas for Carcinoma With Studies of Its Blood Supply, Surg, Gynec & Obst 74 137 1942
- 48 Zinninger, M M Radical Resection of Duodenum and Head of Pancreas for Carcinoma of Ampulla of Vater Repair of Pancreatic Fistula Using a Vitallium Tube, Cincinnati J Med 23 174, 1942

THE REPAIR OF NASAL LOSSES

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THE objective of any reconstructive surgical procedure is to restore or improve function. In addition, if the part is a facial feature, the form of the restored part, to be acceptable, must approach the normal as closely as possible. It is my purpose to consider in this report the various types of nasal losses commonly encountered and the methods which, from personal experience, have served best in attempts to correct these disfigurements.

If the motivating factor is a desire to approximate normal form and function, it seems obvious that one must be thoroughly familiar with, and hold firmly in mind at all times, form, structure, and function as a model.

Structure—The external nose, structurally, is a hollow pyramid in the midportion of the face which rests on the maxilla. The walls of this pyramid are made up of skin and subcutaneous tissue, stretched over a framework of bone and cartilage, and lined by mucosa.

The skin over the bony bridge is thin, elastic, and loosely attached, while that of the tip is thicker, stiffer, and more bound to the framework. Under the skin is a fine, interlacing network of muscles innervated by the facial nerve. These muscles can wrinkle the skin, elevate or depress the tip, and narrow or widen the nostrils. In the lower animals their function is useful, but in man function has been practically lost and is of little importance. This is fortunate since one cannot restore lost muscle.

The normal nasal skin has a texture and color which blends imperceptibly with the surrounding skin of the face. This may seem obvious but is of importance. There is often a temptation to reconstruct nasal losses with tissue from some area normally covered by clothing. The advantage, of course, is that the scar of the donor area is hidden, but the resulting nasal repair is usually disappointing. It is best, if possible, to repair nasal losses with skin which will match in texture and color.

The skeleton of the nose is half bone, half cartilage. The upper bony half of the nose resting on the maxilla can support itself, but the lower cartilaginous portion cannot in itself completely maintain the contour of the nose without the added support of the nasal septum. The cartilaginous skeleton is composed of two symmetrical pairs, the lateral cartilages and the alar cartilages. These are so arranged that the alar pair can move in telescopic fashion over the lateral pair.

In nasal losses it is impractical and unnecessary to attempt to restore the nasal skeleton in detail but it can be simulated fairly well by either a long cantilever strut resting on remnants of the nasal bones if present or, in some

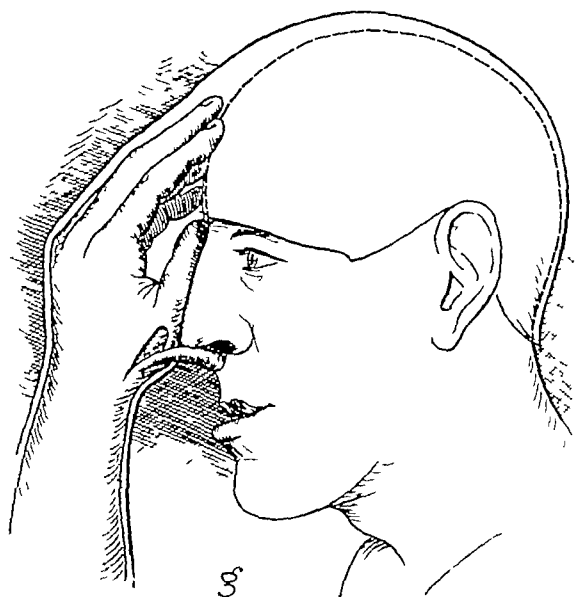


Fig 1—Columellar absence. If the columella is lost or absent, it can be repaired from adjacent tissue such as the upper lip or by tissue brought in from a distance. The latter course was decided on here since the upper lip was so deficient. The complete deformity is an almost constant one which occurs when the premaxilla is excised in double harelip. The final restoration of which the columellar construction is only a part was accomplished by advancement of soft tissues on maxilla, transference of lower lip flap to upper, lowering nasal profile line, repositioning alar cartilages, removal of protruding lower border of mandible and construction of an upper denture. This was done in nine operative steps.

The columella was constructed from a small hand flap as shown in *g*. The way this small addition helps to correct the deformed nasal tip can be readily seen in comparing the preoperative photographs *a, b, c* with the final appearance, *d, e, f*.

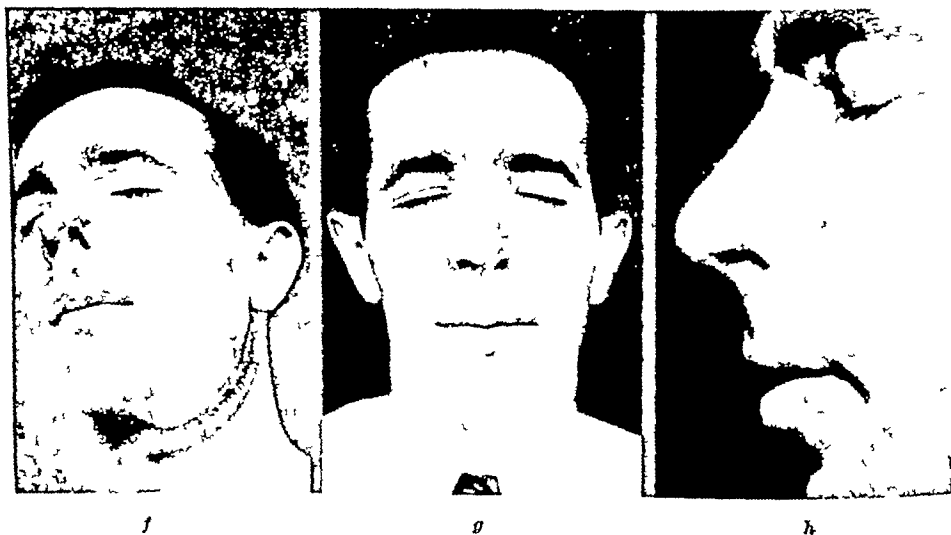
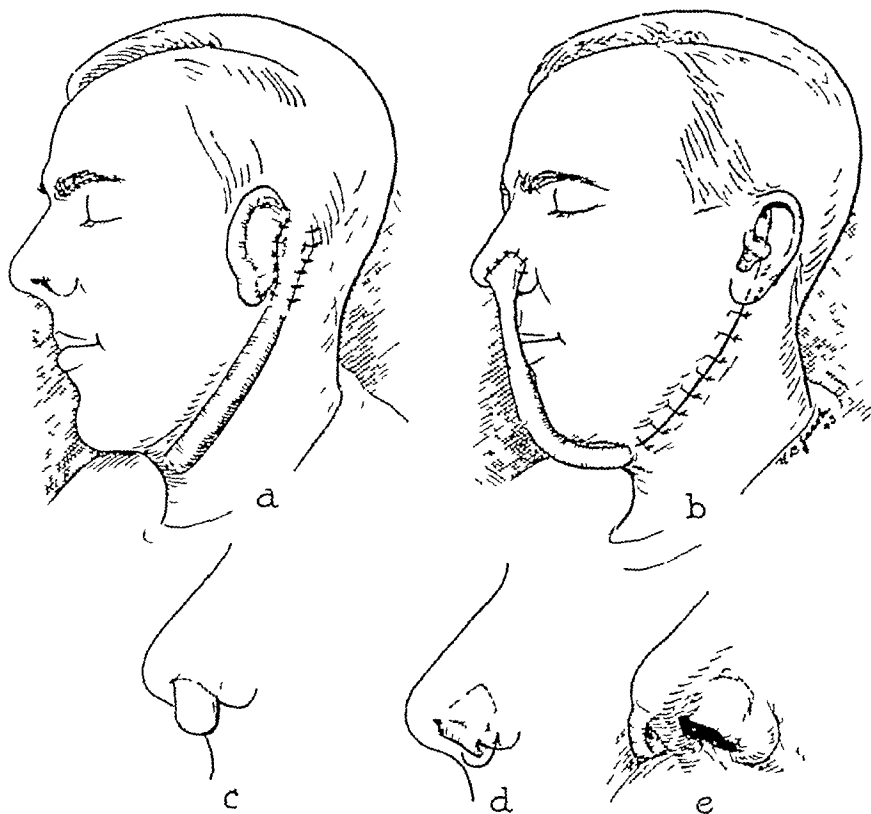


Fig 2—Alar rim loss. This man lost the edge of the left ala from a dog bite (*f*). Such losses can be repaired by adjacent nasal or nasal-cheek flaps. In this instance tissue to replace the lost alar rim was obtained from the postauricular region. It was carried on a tubed pedicle in the submaxillary region (*a*). This method leaves little noticeable scarring but is not as satisfactory as either adjacent nasal flaps or small forehead flaps. The weight of the pedicle tends to cause poor healing at the nasal attachment, a difficulty not present when flaps are turned from above downward. The color match is good but the texture is softer and finer than either forehead or nasal skin (*h*).

instances, by the addition of a right-angled post at the lower end resting on the nasal spine of the maxilla

The lining of the normal nose is, for the most part, mucosa. The nares in part are lined for a short distance by skin which changes into mucosa. The lining normally secretes mucus which keeps the interior of the nose moist. In extensive nasal losses there is no handy site from which enough mucosa can be safely taken for repairs. Skin is not an entirely satisfactory substitute for mucosa but is the best available. The greatest objection to a nasal lining of skin is that the epithelium macerates and gives rise to an unpleasant odor. This occurs more often when the lining is composed of a flap of skin and subcutaneous tissue than when a free graft is used. This is probably so because, in the flap, oil and sweat glands continue to function and these secretions mixed with the constantly desquamating outer epithelium give rise to the odor. A free graft of skin of less than full thickness is less objectionable in this respect but has other disadvantages. Among these are the lower percentage of complete take, and the tendency of the reconstructed anways to contract.

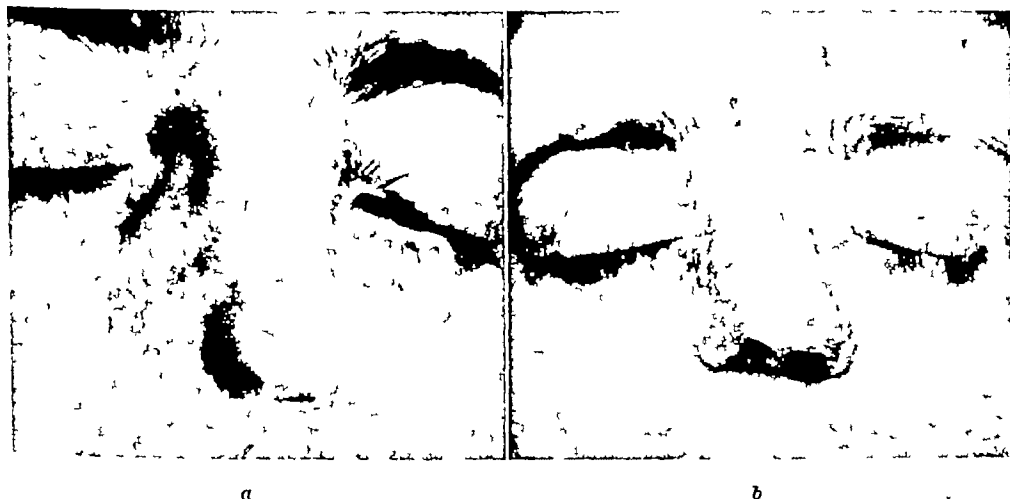


Fig 3—Loss of lining. This woman had almost complete obstruction of the nares following spontaneous healing of a chemical burn (a). The alae were mainly present but contracted inward and healed to the columella. This loss was primarily of lining within the nostrils. Nasal breathing was restored by dissecting the alae free from the columella and replacing the lining by Thiersch grafts held in place on wax forms (b).

Function—The nose is an accessory organ of respiration. Air taken in through the nose is warmed, moistened, and to some extent filtered. This function is, of course, not indispensable as air can be taken in through the mouth. After reconstruction this function is not usually entirely restored to normal.

Smell is, of course, a primary nasal function, although no longer highly important. Loss of the external nose does not appreciably affect this sense.

The nose is also an important part of the speech apparatus. In certain nasalized sounds it is important that air pass simultaneously through mouth and nose. Moreover, the air-filled nasal compartment together with the paranasal sinuses forms a sounding board which gives resonance to the voice.

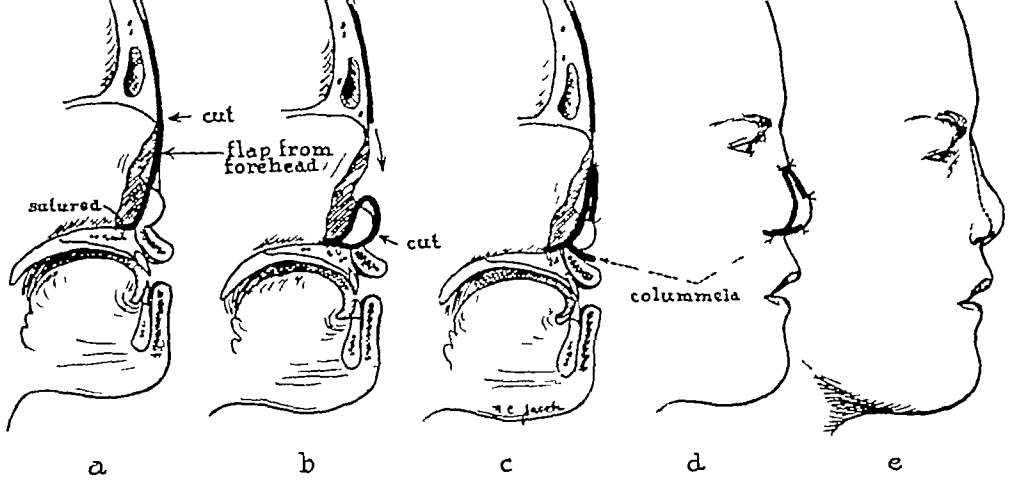


Fig 4—Loss of lining with contracted covering. Congenital syphilitic destruction of the nose such as this girl had is no longer common. The deformity presented is rather typical. The ulcerative process destroyed the nasal septum and columella and presumably adjacent nasal lining. Healing resulted in dense scar contracture which caused the nose to shrink inward (f, h). The problem was to dissect out the scar so that the nose could be brought forward and expanded and losses replaced. A forehead flap was let into the nose through a transverse incision above the alar cartilages after the scar tissue had been dissected out from an intraoral approach and ultimately used to replace lining of the nasal floor and lower half of the nose (a, b). The remainder of the flap was used to construct the columella (b, c) and lengthen the nose (c, d). The latter was done by a crescentic insert of both lining and external skin just below the nasal bones. In g and h are shown the lengthened and advanced nose and the reconstructed columella. The entire forehead flap was used and the split graft used to cover the forehead should be excised and a full-thickness graft applied. The parents however, did not bring her back to have this done. The amount the nose was brought forward is shown in e.

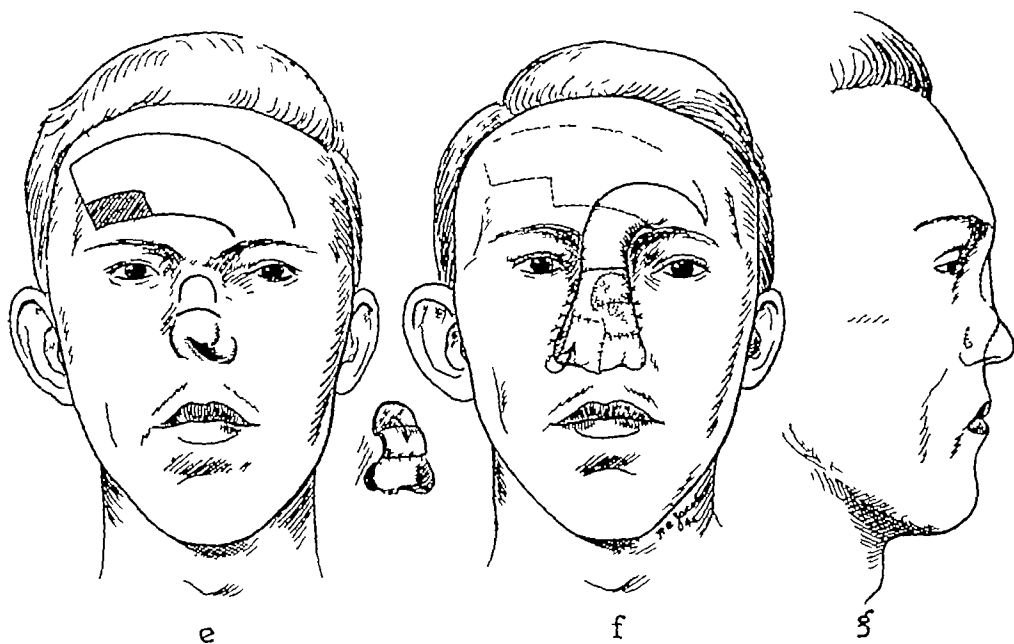
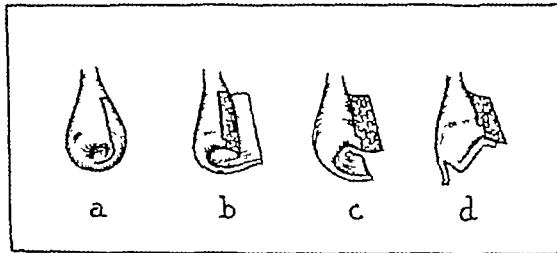


Fig 5—Partial loss with distortion. In all reconstructive procedures an adequate plan should be formulated before starting. This patient's past history probably represents inadequate planning. At the age of 5 years most of the nose was torn away in an auto accident (a b). He was 20 years of age when I first saw him. In the fifteen years since the accident he had been subjected to twenty-three surgical procedures in another city. There were incisional scars on the forehead and on the right upper arm where flaps had evidently been lost, and scars on the thighs where free grafts had been obtained. So much had been done and so little accomplished that the parents were convinced that nothing could be done. This belief was strengthened by the fact that some of the failures had been explained by statements that the boy's blood was bad. They were finally convinced that there was no reason an acceptable repair could not be done. The plan was to save the columella and left ala bring them down into normal position line the mid-portion of the nose with a flap from the bridge and reconstruct nasal covering and lining of the left side of the nose with a forehead flap (c f). This was done in eight operative steps. At a final stage some months later an autogenous cartilage graft was inserted for support and to bring the completed nose to final appearance shown (c, d). Unfortunately the grafted forehead became pigmented.

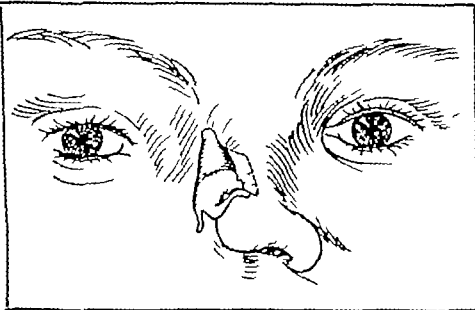
Associated Functions—There are other functions which do not depend entirely upon a functioning external airway but which are aided by their patency. Among these may be mentioned lacrimal drainage, sinus drainage, and the sneezing reflex.

And finally, I believe one must include an esthetic function which is not mentioned in physiologic teaching. This function has been and still is a difficult one for the medical fraternity to accept, but is as real as nasal breathing. It is a fact that in most human beings there is a desire, more powerful in some than in others, to conform in appearance to a somewhat general norm. A major deviation from the accepted standards may make the individual the object of unsolicited concern and produce reactions of self-consciousness and feelings of inferiority. The psychic disturbance varies with the individual, in some it may be of no importance, in others of such magnitude that it is out of proportion to the actual deformity. And on the economic side, a nasal disfigurement may be at times as great a handicap as a disabled hand.

The Nose and Its Relation to the Face—There are certain facts about the relationship of the nose to the face which should be kept in mind in any nasal



A



B



C

Fig 6—Congenital half nose. This is not a true loss of nasal substance but is due to cessation of the normal embryologic process of nasal formation. The deformity is rare but if enough tissue is present which was to be nose it should be saved. Usually there is a fleshy mass attached above the external canthus which represents the abortive half of the nose. This at times may be lined centrally by mucosa. In this case the mass was solid the invaginated area on its base not having progressed to formation of a tube (e). It was attached by a pedicle about $\frac{1}{4}$ inch in diameter. As the mass was to have become nose it would seem that it should have the same growth rate and other requisites for satisfactory repair material. It was, therefore, decided to move the mass down into position allow it to grow and at a later time supplement it, if necessary and perhaps open an airway. This was done in six operative steps one of which included correcting the displacement of the right internal canthus (A [a, b, c, d], B, C). The child is now 12 years of age (g, h). The nose is short and will soon be lengthened by an insert of lining and covering in the mid-portion. As roentgenograms show absence of all sinuses on the right and only one large airway I have decided to leave the right side as a dummy without nasal function.

reconstruction These are not as important in repairing nasal losses as in altering the shape, size, or position of the distorted but intact organ This is true because one is limited in reconstruction to producing a structure which meets gross requirements but never has the finer aspects of the normal The following facts suffice in repairing nasal losses

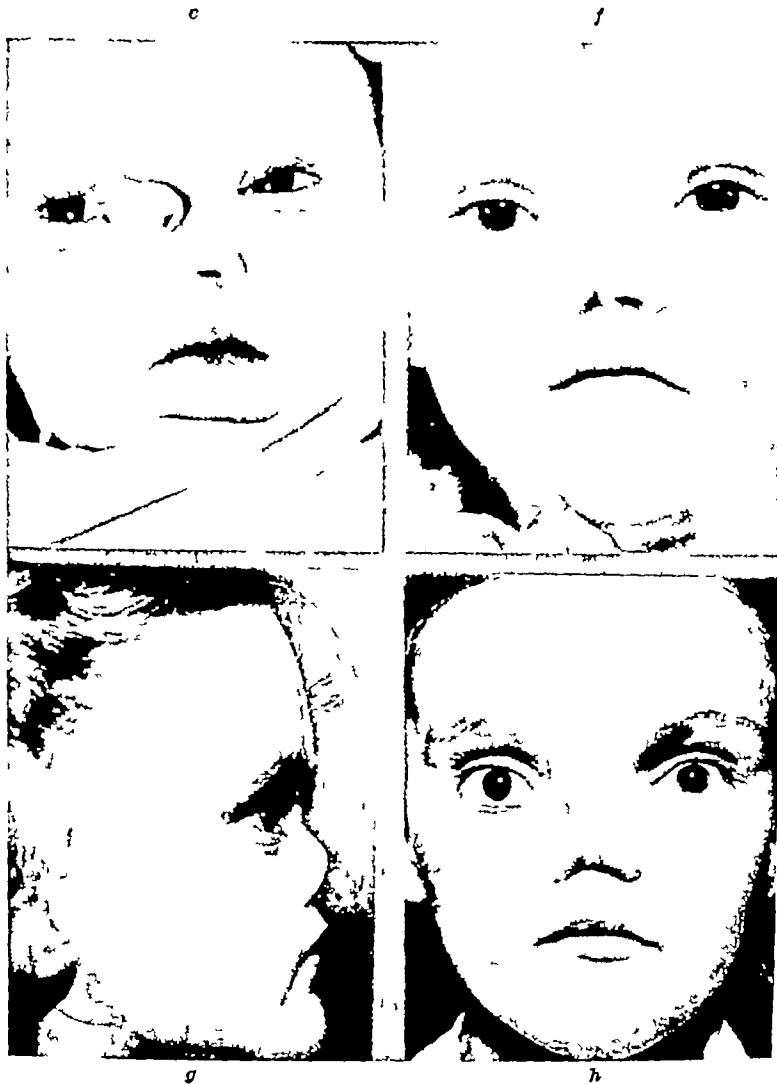


Fig 6 (For complete legend see opposite page)

The normally proportioned nose when viewed from the front should make up the middle third of the face The distances from the hairline to the root of the nose, from that point to the tip of the nose, and from the lower chin to the nose should be roughly equal to one another Deviations from this relation makes the nose either noticeably short or noticeably long The distance between the eyes should equal the length of the palpebral fissures, and, in turn, be equal to the distance from ala to ala at the base of the nose The nose is in the exact midline of the face and its two halves are symmetrical

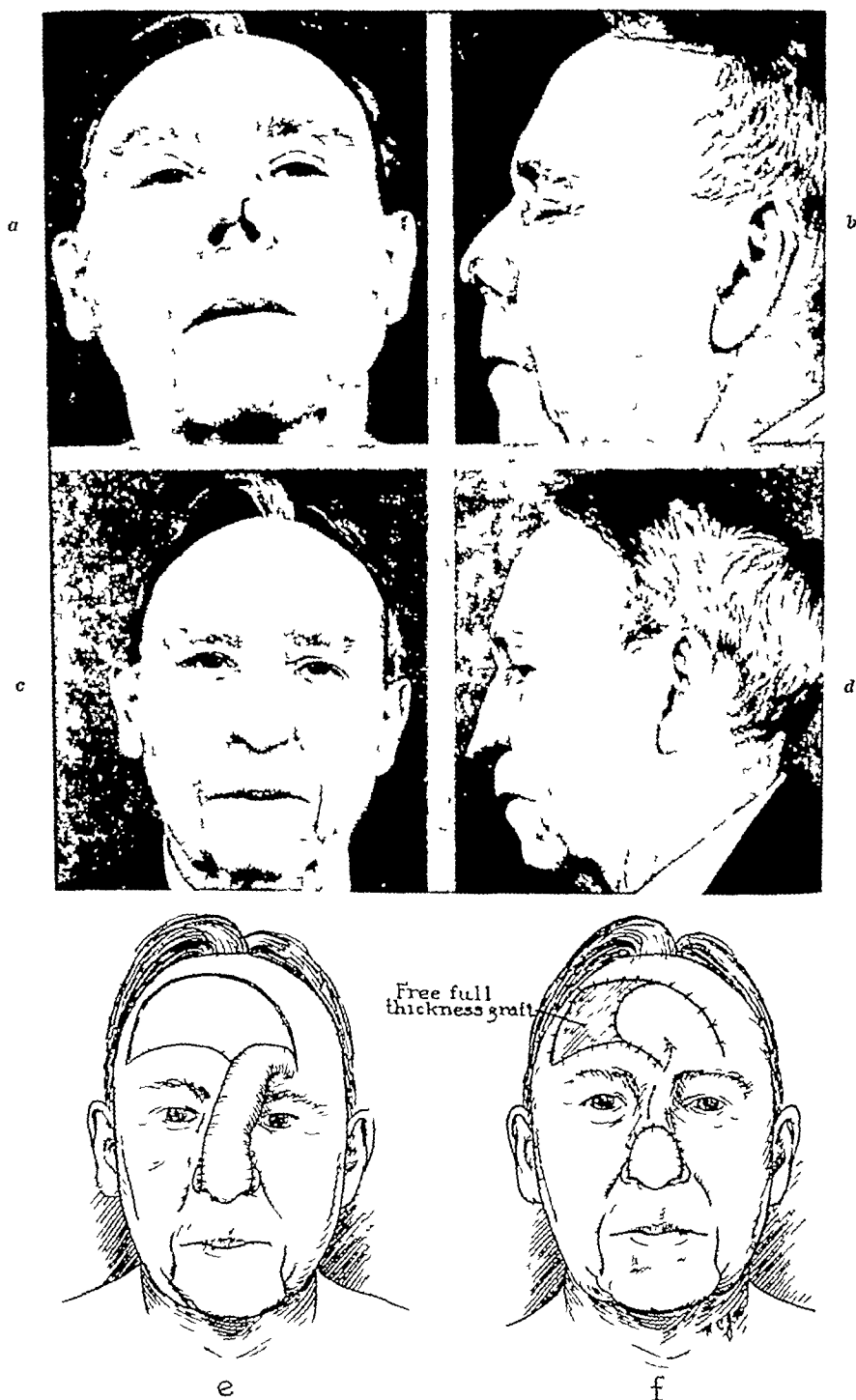


Fig 7—Total loss of lower half of nose. This man had a persistent, recurrent, basal-cell carcinoma of fifteen to twenty years duration (a, b). Radium and electrodesiccation had been used many times. Because of the disfiguring loss already present, I advised that the lower half of the nose be destroyed and a new one constructed. The nose was removed and constructed in five operative steps (e, f). This man has almost no forehead disfigurement since the forehead was grafted with a full thickness graft from the clavicular region which matches almost perfectly (c, d).

Normally the vertical height of the upper lip is about one-third of the nose to chin distance. This has a bearing on the harmonious relationship of the nose for if the lip is short, the nose looks longer from in front, while a quite long upper lip may compensate for an abnormally long nose. The alae curve downward gracefully and symmetrically to enclose the nostril openings whose axes should be vertical. From in front the nostrils and the base of the columella are barely visible. The pyramidal mass of the nose should rise steadily and symmetrically, without lateral excrescences or indentations, from its base at the alae to its apex at the root where nose joins forehead.

The normal profile view of the nose varies greatly. However, there is a relationship which is considered most pleasing. The dorsal line of the nose should be almost but not quite straight. The angle formed by the nose with the vertical line of the face can vary only within rather narrow limits without being noticeably abnormal. An angle below 30 degrees gives an appearance of flatness while one very little above 40 degrees will be unduly prominent. The columella in profile forms an angle of 90 to 105 degrees with the upper lip. The larger angle is the more pleasing, probably because in childhood and the teenage the nasolabial angle is always greater than 90 degrees and gradually decreases with growth and age. Hence the turned-up tip is associated with adolescence and in the adult gives a more youthful appearance.

These facts are well kept in mind in nasal repairs. However, they are of somewhat theoretical interest since it is not possible to reproduce the finer details of the normal nose. One should be able to construct a nose which fulfills the requirements of symmetry, length, profile angle, general relationship to the face, and functions in a nearly normal manner.

Partial and Complete Losses—Most of the deformities comprising partial and complete losses are due to either injury or disease or its treatment. In occasional instances there may be congenital absence of parts of the nose. When all three elements of the nasal wall have been lost, repair is generally carried out by reconstructing the covering and lining from skin and, if necessary, replacing the lost framework whether bony or cartilaginous with cartilage. The skin in most instances is secured from the forehead. This site is used even though it means some disfigurement because the color and texture of the skin is correct and its thickness is such that it accommodates itself easily to modeling. In our experience the scars on the forehead are more readily accepted by the patient than a flabby, soft-skinned, off-color nose. In partial nasal losses those parts which remain, if acceptable, are saved and used in the repair. This at times may mean moving them from distorted positions, but this is worth while since, if not deformed, a displaced ala, for example, is of better contour than one that can be made.

The repair of a full-thickness loss of the nose in our hands resolves itself into about five operative steps, three of which are done under local anesthesia. A flap of the correct size and shape is elevated and delayed on the forehead. These two steps are done on two occasions about ten to fourteen days apart. At the third step under general anesthesia without hospitalization.

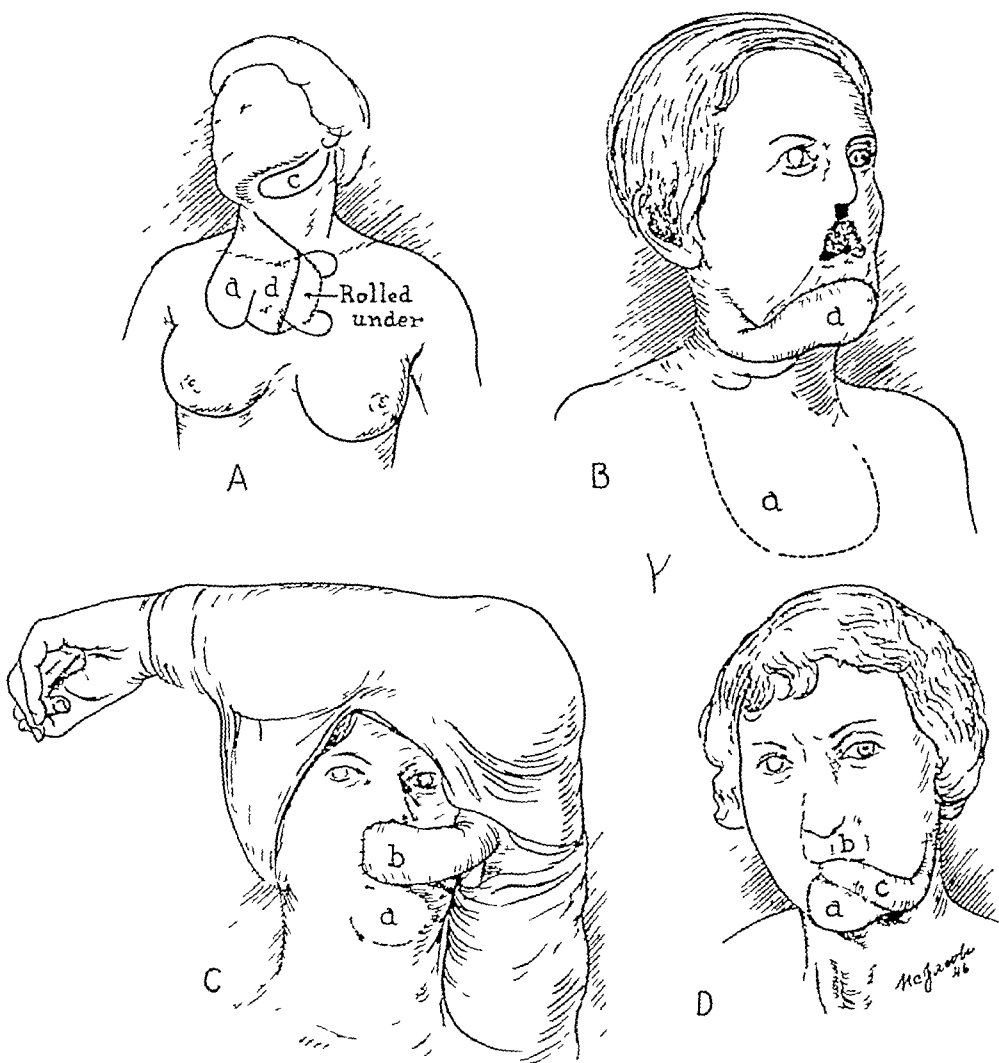


Fig 8—Nasal losses with surrounding loss of tissue. When there is extensive loss of the nose there is often loss of the adjacent tissues as well. Since these form the foundation on which the nose rests the plan must include their restoration. The lip and cheek if absent must be rebuilt before the nose. In this instance the original plan was to form the upper and lower lips from a bilobed chest flap (A). However this proved unwise since the flap for the upper lip was lost and could be used for the chin only (B). A change of plans was made and the upper lip made from an arm flap (C). The nose was then constructed in the usual way from a forehead flap. The lower lip was then brought to better contour by a tubed neck flap (D). The original condition (e, f) was improved to the final (g, h).

Fig 9—Prosthesis. An artificial nose is particularly valuable in a case such as this. The woman had a history of repeated recurrences of basal-cell carcinoma over a period of fifteen years. She had been treated elsewhere and at one time had had the left half of the nose reconstructed from an arm flap. This had been removed because of recurrence. The defect (a) resulted from extensive cauterization and subsequent sequestration of the bone of the alveolar ridge, hard palate and medial walls of the antra. Because of the repeated recurrences a long period of observation was advised following healing. During this time she was helped greatly in speech deglutition and appearance by the denture (a) and the prostheses (b, c) which we constructed for her.



Fig 8 (For complete legend see opposite page)

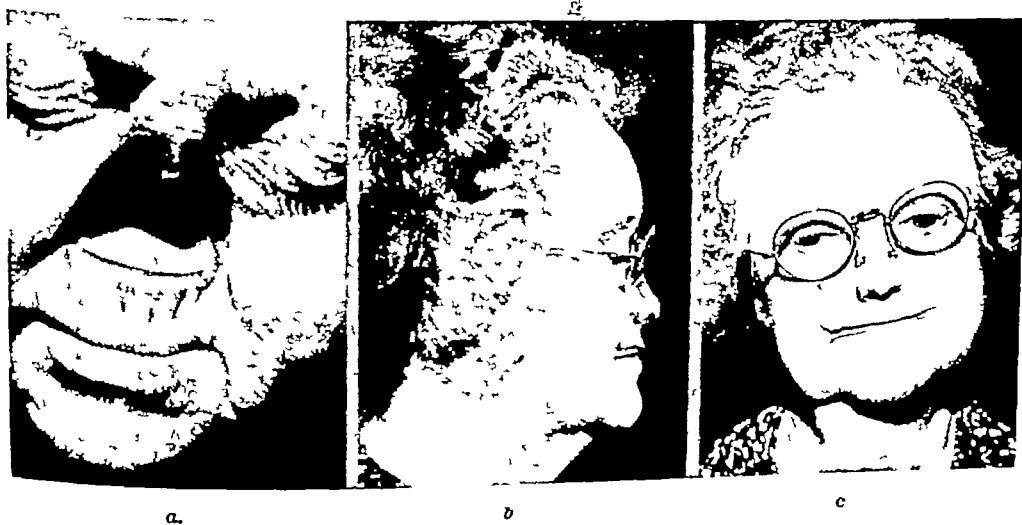


Fig 9 (For legend see opposite page)

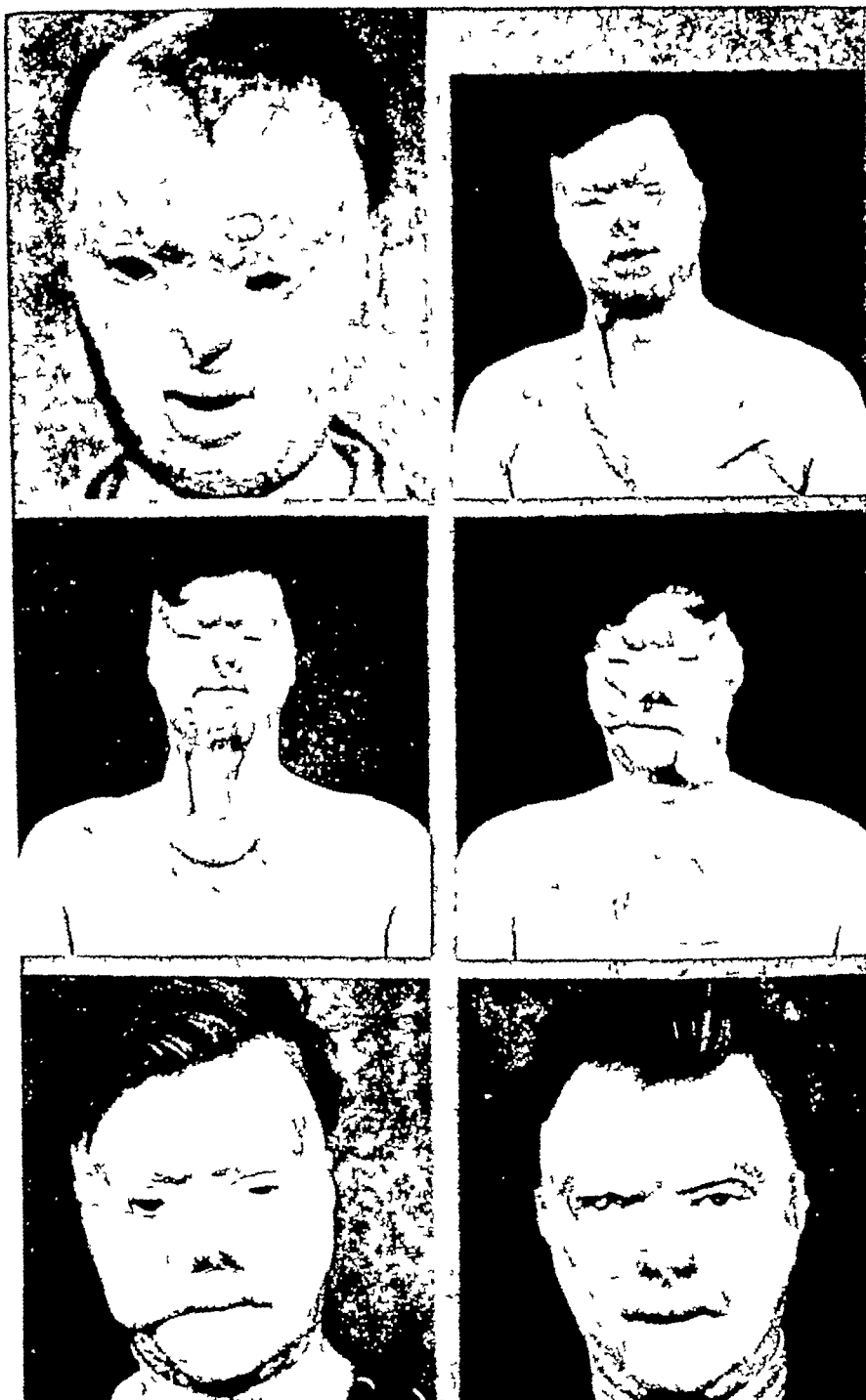


Fig 10—Replacement of nose in a general facial reconstruction. One is occasionally called upon to resurface and readjust to normal most of the face. The skin of this man's (a) face had been burned off. The alae of the nose, the eyebrows and helices of the ears were gone. The eyelids were contracted off the globes and it was barely possible for him to open his mouth. The right cornea was ulcerated when first seen and hence the first thing done was to dissect free the eyelids produce lid margin adhesions and free graft the lids. In spite of this vision of the right eye was lost from scarring. The general plan was to resurface the cheeks lips and nose from a chest flap (g h). This was moved upward on bilateral tubes (b c, d). The forehead and eyebrows were free grafts and the rims of the ears small neck tubes. Such a nose is acceptable (f) since its color and texture are similar to the reconstructed surroundings.

anesthesia, and in the hospital, the flap is turned into place and its end folded under for the lining. At this step the forehead is grafted with either a full-thickness or thick split-thickness free graft of skin. In four to six weeks the flap is securely grown into place and at this time the pedicle is divided and whatever remains returned to the forehead. This step is done in the hospital under general anesthesia. The return of the pedicle means that some of the previously grafted area on the forehead is discarded, but this has proved to be a better plan than allowing the forehead wound to remain open to granulate and then grafting at the time of the pedicle return. A varying period of two to six

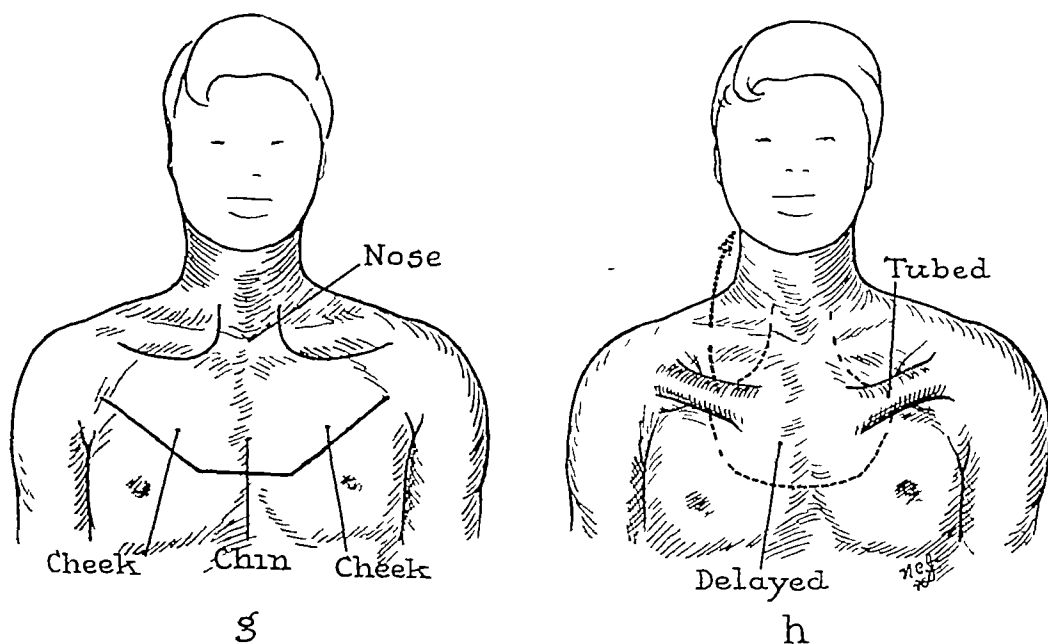


Fig 10 (For complete legend see opposite page)

months is then allowed to pass so that whatever shrinkage there may be will take place. During this interim the skin of the new nose softens and decision can be made as to whether support may be needed. The fifth and usually last step is for necessary modeling and perhaps the insertion of a cartilage graft to support the tip and dorsum.

In nasal losses, prostheses are of value although limited due to the fact that most patients prefer a nose from their own tissues. However, in the occasional instance where surgery is contraindicated due to age or physical condition, a properly constructed prosthesis makes the patient less conspicuous and more comfortable. A greater usefulness is in the covering of defects following the eradication of malignancy where a waiting period is at times necessary before repair can be safely undertaken.

THE PROBLEM OF CANCER OF THE BREAST

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CANCER of the breast is a problem which concerns the physician, the surgeon, and the radiologist alike. It concerns the physician primarily for it is a disease that requires no special training, no unusual instruments for diagnostic purposes, but on the contrary a close relationship between the physician and his patient. Ordinary observations of the patient combined with a periodic examination by the physician will go far toward recognizing abnormalities of the breast in their early stages. It has been a source of concern that medical students will spend so much time in physical diagnosis of the chest where in the absence of symptoms so little is usually found and where the x-ray and electrocardiogram play such a part in diagnosis. So little time and space is allotted to a careful evaluation of the female breasts when only the ordinary senses are required. It is a concern to the surgeon for his only hope in prolonging the life span of his patient is in seeing the condition early. He has nothing new to offer beyond the well-standardized radical surgical operation which was described by Halsted, an operation which has contributed materially in those patients without glandular involvement. Any further improvement in technique may add to the patient's comfort but very little improvement in clinical results can be expected from this type of treatment. The radiologist has extended himself trying to justify deep therapy in the treatment of cancer of the breast. At one time preoperative therapy was thought to be of definite value only to be discarded at a later date. Likewise, there was a period in which postoperative irradiation was used in all cases. Subsequently, this was changed in most clinics and only those cases showing glandular metastases were subjected to this type of therapy. The results of surgery combined with postoperative irradiation have not even justified this, and in many clinics today deep therapy for cancer of the breast is restricted to skeletal metastases for symptomatic relief. From the evidence at hand this latter course is the most reasonable one to assume. For really, what does one hope to accomplish by irradiating a chest wall that has been stripped of its contents? No one has shown conclusively that the last cancer cell can be destroyed by irradiation alone. In fact, the opposite has proved to be the case in that patients coming to surgery or post-mortem have consistently revealed cancer cells to be present in the irradiated areas. Such being the state in which we find ourselves, we must attack the disease by other methods. Our ultimate hopes rest either in prevention or in some new method of therapy or more probably in a combination of both. In the absence of a more specific therapy, our present energy should be directed toward prevention and

early diagnosis, for the best results have been obtained in those patients in whom the disease was local and in whom radical mastectomy had been performed

In 1903 the death rate from cancer of the breast was 5.5 per 100,000 population, in 1933 it was 9.9, and in 1944 it was estimated at 15. Recent reports have indicated that the annual incidence in the state of New York is 60 per 100,000 of population, and that 37 out of every 1,000 women reaching adult life will develop cancer of the breast. The incidence of carcinoma of the breast is much higher in single women than in married women over 35 years of age. This report is significant in attacking the problem, for why should single women getting closer to the menopause find themselves with an incidence so much higher? Cancer statistics are difficult to obtain, but it is generally stated that there are between 50,000 and 60,000 women with cancer of the breast and that between 15,000 and 20,000 die annually from the disease.

In attacking the problem from the prevention angle, there are many factors to be considered. Kuramitsu and Loeb,¹ in experimental studies on animals, concluded that the cessation of nursing had a more profound and dominating evolutionary effect on the breast than castration. The effects of castration became manifest as soon as suckling ceased. Loeb² showed that castration at an early age greatly decreased the incidence of mammary tumors in a strain with a high spontaneous incidence. Bittner³ and co-workers in numerous experiments in mice have shown that there is a milk factor involved, but no such factor has ever been shown to be present in the human being.

The relationship of nursing in the prevention and castration in the treatment of cancer of the breast deserves more than a passing statement. Cancer of the breast is less common in women who have borne many children and who nurse their offspring for a long period of time. On the other hand, in light of Little's work in mice it would seem more plausible that if there is a known history of cancer of the breast in the family, nursing should not be resorted to in a newborn female child. This might conceivably be a factor in eradicating the disease.¹

Another influence to be considered is that of the estrogenic effect on mammary growth. Much experimental evidence has been accumulated and some clinical cases reported to warrant some association at least. To mention only a few, Lacassagne⁴ was able to show experimentally that the administration of estrin increased the incidence of spontaneous carcinoma in female mice in strains characterized by a low percentage of spontaneous mammary tumor. Geschickter⁵ reported producing mammary carcinoma in rats belonging to a strain in which no spontaneous mammary tumors occur. The time required for the appearance of the mammary cancer was reduced if a higher daily dose of the estrin was injected or if compounds of greater estrogenic potency were administered. Allen⁶ criticized experiments dependent for their success on the administration of massive doses of estrogen to produce carcinoma, stating that the secretion of endogenous hormone from the animal's own glands could not possibly approximate the large doses employed experimentally for this purpose. He stressed the possible danger of long-continued high levels of the hormone which is a natural constituent of the normal female body. His results also indicated that

unless an individual is especially susceptible there are levels of estrogenic treatment which, so far as is known at the present, are below the carcinogenic level. He concluded by stating that if therapeutic levels can be established within a safe range, the danger can be minimized.

It is generally recognized that glands other than the ovary produce hormones capable of producing growth of the mammary tissue such as the pituitary, adrenal, and testes (Riddle). Cramer and Horning⁸ believed that the pituitary thyrotropic factor antagonizes the susceptibility to estrogen and was able to prevent spontaneous mammary cancer in mice by the administration of the thyrotropic hormone of the pituitary gland. Clinically there have been some case reports suggesting a relationship between cancer of the breast and endocrine therapy. Allaben and Owen⁹ reported a case of adenocarcinoma of the breast coincidental with strenuous endocrine therapy in a single woman of 48 years who received 258,000 units of estrogen over a period of one year for low blood pressure. She had not reached the menopause, but menses stopped shortly after the injections were begun. During the time of therapy she noticed occasional fullness of the breast. Auchincloss and Haagensen¹⁰ likewise reported a case of cancer of the breast in an unmarried woman of 47 years coincidental with estrogenic therapy, and suggested that the carcinoma might possibly have been induced by estrogenic therapy. In the light of the facts involved in their case they concluded that estrogenic therapy should be avoided (1) in large or prolonged doses, (2) when there is a family history of breast cancer, (3) without initial or repeated clinical examinations, and (4) in patients with chronic mastitis, carcinoma, or any form of breast neoplasm, either before or after surgical or radiation treatment. Parsons and McCall,¹¹ in SURGERY (1941), reported a case of a married woman, mother of one child, with a carcinoma of the breast, who had received estrogenic therapy over a period of three years. Although they felt definite proof was lacking, they suspected at least the estrogens may have played a very major etiologic role in the development of the malignant adenocarcinoma that was present in the breast. There no doubt will be many more additional articles on cause and relationship, but to date the evidence of malignancy of the female breast following endocrine therapy is not very convincing.

The heredity factor of cancer of the breast is not very clear. The experimental evidence is most confusing and just as inconclusive. In the human being it would seem advisable to consider the relationship from the standpoint of organ specificity. A family history of cancer generally is of little importance, but when there is a record of cancer of a specific organ through several generations one is led to believe that there is some characteristic which has been handed down.

The patient herself is in the best position to recognize an abnormality in the breast early. It is true that often the patient may be disturbed about a lump when it is not actually present, but such an error is not a serious one. Periodic examination of her breasts about the mid-period will not make her a cancer phobic, but on the contrary will tend to fortify her if a lump is found for she

then is aware that the condition has been recognized early. More emphasis, therefore, must be placed on making the individual responsible in part at least for her own health.

The symptoms and signs of cancer of the breast are well recognized and need no enlarging upon, but it should be emphasized that any lump in the breast is abnormal. If the woman is single and close to the menopause it is even more significant. If the lump is painless and nontender to palpation it should be considered a potential malignant lesion. The presence of axillary glands in a woman with a lump in the breast is significant, and one can tell with a fair percentage of accuracy when axillary glands are involved. When they are thought not to be involved, there is a chance for error.

There is no single condition that presents so many problems in treatment as that of cancer of the breast. Presented with a woman who has a lump in the breast, how are we going to treat it? It is generally agreed that one should be prepared to go ahead with a radical mastectomy once the diagnosis is established. A surgeon treating breast tumors should have a comprehensive knowledge of gross pathology, for in most instances the diagnosis can be made once the tumor is examined. Although the radical operation is the operation of choice, there are instances when a simple mastectomy combined with removal of axillary glands appears to be preferable. Fortunately, today we see few cases of ulcerating lesions of the breast, probably as a result of education both to the public and the medical profession. When an ulcerating lesion is present the infection should be controlled by x-ray therapy and chemotherapy followed by a simple mastectomy.

The value of x-ray therapy preoperatively has been generally discredited and likewise discarded. In our clinic we have likewise discarded the use of it postoperatively, either in the absence or presence of axillary involvement. Radiation therapy is used in those cases with metastatic bone lesions purely as a palliative procedure. If a recurrence is noted locally or glands reappear in the axilla, radiation therapy or surgical excision is resorted to.

In a series of 193 cases reported by Stabins and Dowdy,¹² some interesting observations were noted. One hundred fifty-nine, or 83 per cent, occurred in patients between the ages of 40 and 70 years, with about an equal incidence in each of the three decades. In seventy cases, or 36 per cent, there were no pregnancies. In 122 cases, or 63 per cent, the lump was located in the upper outer half. One hundred fifty-six patients, or 80.8 per cent, were subjected to radical mastectomy. Eighty-six were found to have axillary metastases with a five-year survival of 27.9 per cent, the remaining seventy without axillary metastases had a five-year survival of 50.0 per cent. These are not a selected group. The worst results were in those patients with the primary tumor located in the inner quadrant. When the condition had spread to involve the axillary glands, internal metastases were noted early and the five-year survival rate was only 8.3 per cent. In a study of 298 cases no appreciable difference in the incidence of elephantiasis could be found between the group showing positive axillary nodes and the group which did not.

Holman, McSwain, and Beal,¹³ in a study of 100 cases of elephantiasis following radical mastectomy, came to the following conclusions (1) primary skin grafting had no influence on the occurrence of swelling of the arm, (2) swelling of the arm could not be assumed to signify recurrence of the carcinoma, (3) the presence or absence of metastases to the axillary nodes at the time of operation had no bearing on the swelling, and (4) by far the greatest factors in the cause of swelling of the arm were infection and roentgen-ray dermatitis. In some clinics skin grafting is resorted to primarily on the assumption that it decreases the incidence of local recurrences. There is not sufficient evidence to support this contention. However, skin grafting wisely used is of value in improving the function of the arm by leaving the wound open, thus avoiding tension and contracture in the axilla.

In recent years the studies on the influence of ovarian function on mammary growth in animals has resulted in clinical research based on the removal of the estrogenic influence in women with cancer of the breast. X-ray therapy to the ovaries in bone metastases with consequent sterilization has resulted in partial or complete recalcification of metastatic bone foci far removed from the area exposed to irradiation with no therapy directed to the local lesions. Stimulated by these findings, castration by x-ray therapy was advocated in those patients with carcinoma of the breast who had not reached the menopause. Objection to this method of sterilization is based on the knowledge that the entire estrogenic influence is not removed, that sterilization may not be complete, and that subsequent pregnancy, a most serious complication, might follow. When breast carcinoma is noted during pregnancy or lactation, x-ray sterilization should be considered. In pregnancy, interruption is a necessity before the fourth or fifth month if the cancer is to be controlled. Certainly subsequent sterilization is a necessity if control of metastases is to be achieved. In general, it would be much safer to forbid pregnancy or the use of estrogens in all cases of mammary cancer. Horsley¹⁴ reported on twenty-five patients with bilateral oophorectomy and concluded that all patients with breast cancer and skeletal metastases who have not reached the menopause should have sterilization. Farrow¹⁵ stated that about one-third of the premenopausal cases of cancer of the breast can be materially benefited by castration.

It would seem that castration is a most radical procedure to remove the estrogenic influence in the absence of skeletal metastases. Possibly some glandular therapy antagonistic to the estrogens might be used. Testosterone has been under investigation for some time following the dramatic results published with stilbestrol in carcinoma of the prostate. Some reports are encouraging although not too convincing. We are approaching the problem of inhibiting the estrogenic influence by such forms of therapy in our clinic, but to date are in no position to venture any opinion.

CONCLUSIONS

1 Cancer of the breast concerns the physician, the surgeon, and the radiologist alike

2 Cancer of the breast ranks number one in incidence of malignancy

3 Prevention and early diagnosis represent the best approach to the problem

4 The relationship of estrogens to androgens in cancer of the breast is still to be determined

5 The association of elephantiasis with cancer of the breast is discussed

6 The limitations of x-ray therapy are stressed

7 Radical mastectomy is the preferable method of treatment

REFERENCES

- 1 Kuramitsu, C, and Loeb, Leo' The Effect of Suckling and Castration on the Developing Mammary Gland in Rat and Guinea Pig, *Am J Physiol* 56 10, 1921
- 2 Loeb, Leo Science 42 912, 1915
- 3 Bittner, J T Relation of Nursing to Extra Chromosomal Theory of Breast Cancer in Mice, *Am J Cancer* 35 90, 1939
- 4 Lacassagne, A A Comparative Study of the Carcinogenic Action of Certain Oestrogenic Hormones *Am J Cancer* 28 715, 1936
- 5 Geschickter, Charles F Estrogenic Mammary Carcinoma in Rat, *Science* 89 35, 1939
- 6 Allen, Edgar Ovarian Hormones and Female Genital Cancer, *J A M A* 114 2107, 1940
- 7 Riddle, Oscar Lactogenic and Mammogenic Hormones, *J A M A* 115 2276, 1940
- 8 Cramer, W, and Horning, E S The Prevention of Spontaneous Mammary Cancer in Mice by the Thyrotropic Hormone of the Pituitary Gland, *Lancet* 1 72, 1938
- 9 Allaben, G R, and Owen, S E Adeno Carcinoma of the Breast Coincidental With Strenuous Endocrine Therapy, *J A M A* 112 1933, 1939
- 10 Auchincloss, Hugh, and Hingensen, Cushman D Cancer of the Breast Possibly Induced by Estrogenic Substances, *J A M A* 114 1517, 1940
- 11 Parsons, Willard H, and McCall, Eugene F The Role of Estrogenic Substances in the Production of Malignant Mammary Lesions, *SURGERY* 9 780, 1941
- 12 Stabins, Samuel J, and Dowdy, Andrew H Carcinoma of the Breast, *SURGERY* 11 898, 1942
- 13 Holman, Cranston, McSwain, Barton, and Beal, John M Swelling of the Upper Extremity Following Radical Mastectomy, *SURGERY* 15 757, 1944
- 14 Horsley, J Shelton Bilateral Oophorectomy With Radical Operation for Cancer of the Breast, *SURGERY* 15 590, 1944
- 15 Farrow, Joseph H The Effect of Sex Hormones on Skeletal Metastases From Breast Cancer, *SURGERY* 16 141, 1944

PILONIDAL CYST AND SINUS

A NEW METHOD OF EXCISION WITH PRIMARY CLOSURE

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MUCH space in the current surgical literature during recent years has been devoted to the description of newer methods of curing pilonidal cyst and sinus. We hope to point out some of the pitfalls of existing methods of treatment and to present a new technique which has yielded good results.

In the past the high incidence of recurrences with any operation other than that of "simple en bloc excision" and open packing led to the almost universal adoption of this simple method of treatment. Patients were thus able to leave the hospital in a few days and receive follow-up dressings in the office or clinic for the next two or three months. There resulted a small loss of man-days from work but the need for repeated postoperative visits and dressings for such a long interval was certainly not ideal. Furthermore, the end result of the "open method" of treatment is a broad scar covered with thin epithelium which is intimately adherent and fixed to the underlying sacrum by scar tissue without the intervention of the normal fat pad. The mobility of the skin and subcutaneous tissue of this region which normally absorbs the force of trauma to which it is subjected in everyday life is thus impaired. The same factors which it is believed play a part in the high incidence of this disease in young adults today continue to traumatize such an area, and ulceration with breakdown of the scar and recurrent sinus formation are common sequelae.

The foregoing remarks should serve as an adequate explanation for the increasing attempt on the part of surgeons during recent years to perfect a technique of excision and primary closure which will reduce the healing time and rate of recurrence. The great majority of such attempts have been disappointing because the primary closures fail to heal per primam and lead to prolonged treatment which is frequently worse than the results of the open method. Such an operation must have as its ultimate goal four essential considerations, namely (1) a relatively short period of hospitalization, (2) primary healing in the strictest sense with a low rate of wound complications and recurrence, (3) restoration of the normal anatomic relationship with the provision of a normal thickness of fat over the sacrum and a minimal scar in the skin, (4) the placing of the final scar lateral to the midline of the sacrum, which would be an added advantage in minimizing the trauma to which it may subsequently be subjected.

In an attempt to achieve the aforementioned results we have familiarized ourselves with most of the newer techniques described in the current literature during the past few years. All have been found lacking in some respect, although the good points of all methods have been adopted in the attempt to perfect a new technique. Thus, the method of MacFee² and later that reported by

Mutschmann and Mitchell¹ (which bears a close resemblance to the former) produce a midline scar with *no underlying fat pad*. Furthermore, in MacFee's series the average healing time of sixty-nine days is too long and due, no doubt, to the fact that in his method it is rarely possible to bring the skin edges together by primary suture so that actually the wound heals by granulation. The recurrence rate of 12.9 per cent, which may be even higher since results are unknown in 21 per cent of the cases, further mitigates against its universal adoption. McCutcheon⁴ has attempted, by the use of four undercut flaps, to secure healing without tension. However, primary healing is not secured and he freely admits that postoperative infection is common, which is, in turn, reflected in the long average healing time of thirty-eight days in his cases. A further objection is that the location and type of final scar resulting from this method may well stand up poorly to future trauma. The best immediate results from primary suture to date are those reported by Shute and associates,⁵ using a type of muscle flap as a means of obliterating dead space and tension. Although eleven wound complications were encountered in forty-eight cases, the total average healing time with their method was under twenty-two days. This is very creditable, and if subsequent follow-up of their series discloses a low rate of recurrence, the method should be worthy of wide acceptance. However, caution must be exercised in reporting "no recurrences," for, in the series herein reported, only one of the recurrences would automatically have come to light of its own accord and all six patients left the hospital apparently healed within thirty days.

Past experience has shown that the postoperative wound complications and high recurrence rate in all attempts at primary closure have been caused by infection and failure to obliterate dead space. The latter undoubtedly leads to the future development of recurrent sinuses as emphasized by Rogers and Hall,⁶ while the former may have the same end result and, in addition, is responsible for extensive hospitalization and loss of man-days from work. Since these lesions are all infected (Rogers and Hall⁶) and since it is well known that fatty tissue is particularly low in its resistance to infection the utmost attention and care with respect to surgical technique must be observed if true primary healing is to be achieved.

Primary closure with primary healing has obvious advantages if the rate of wound complications and recurrences with the resultant prolonged healing time can be held to a minimum. In developing the technique about to be described it is felt that rigid adherence to the principles of good surgery originally propounded by Halsted has contributed more to the end result than has a new incision. These axioms, even at the risk of boredom, are worthy of repetition.

1 *Atraumatic Surgery*—Dissection with the scalpel rather than blunt instruments and avoidance of all undue trauma by gentle handling of tissues are advised.

2 *Absolute Hemostasis*—Absolute hemostasis must be accomplished by the use of fine ligatures to include only the bleeding points, since the tying of large masses of tissue leads to increased necrosis and exudation in the wound. The wound must be dry when closed and those surgeons who will not spend the time

to secure hemostasis will be doomed to failure. In the operation under consideration this is a most time-consuming and tiring procedure and yet an extra thirty minutes in the operating room can well save the patient thirty days of future hospitalization and treatment. Apologies are not necessary for stressing this factor, for residual blood in the wound separates the tissues, produces dead spaces, increases foreign body reaction and scar tissue, and is a potential invitation for the development of infection. It may be added that hemostasis should progress with the dissection since excessive sponging adds trauma to the tissues. Reliance on hot flushes and packs to control troublesome oozing prior to closure is fraught with the danger of recurrence of bleeding in the wound postoperatively.

3 *Suture Material*—Nonabsorbable suture material has been shown to produce less tissue reaction than catgut, as emphasized by Halsted, the finest suture commensurate with the tensile strength of the tissues should be used. Mass ligations, large bites, and continuous or mattress-type sutures must be avoided to obtain the best results. Many observers have attested to the superiority of cotton over silk, particularly in contaminated wounds. Our experience in this operation, where cotton has been used exclusively for all surgery, most of the wounds being sutured with size 80 and nothing larger than size 50 ever utilized, confirms this observation.

4 *Wound Tension and Pressure*—The greatest obstacle to primary closure following excision of pilonidal cyst and sinuses is closure of the large defect without tension and the obliteration of dead space in the fatty subcutaneous layer. The placing of undue tension on these tissues predisposes to ischemia of some degree leading, at the very least, to a lowered resistance of the tissue to infection and a delayed rate of healing, it may even lead to necrosis of tissue with consequent increase in inflammatory reaction, increased dead space, and other undesirable sequelae. Attempts to obliterate dead space and to secure apposition of tissues by the use of mattress sutures to tie the skin down to the fascia over the sacrum will produce the same reaction. A similar objection is raised to any method which makes use of gauze rolls tied to the skin or of any type of final pressure dressing designed, of itself, to aid in the obliteration of dead space and control of hemorrhagic oozing. In fact, in our management of these cases patients are not even allowed to be on their backs or to sit up in bed until the tenth day in order that pressure on the operative area may be reduced to a minimum.

5 *Use of Drains*—It will be at once apparent that if the aforementioned principles are rigidly and faithfully observed there remains no place for drainage of these wounds. It is agreed that these wounds are contaminated, but it is contended that healthy tissues are quite capable of handling this minimal contamination if the described principles of atraumatic surgery are followed. The ability of these tissues to resist infection may be enhanced by chemotherapy, since the commonly offending organisms are of the streptococcal and staphylococcal strains as demonstrated by Shute and associates⁵ and confirmed in this study.

Keeping in mind these principles, a new incision is advocated which has as its primary purpose the provision of a thick flap of subcutaneous tissue and

skin which can readily be swung in from one side or the other to cover the defect created by total excision of the diseased tissue and which can be sutured in place without tension. The necessity and desirability of some form of flap operation were recognized and developed originally by Lahey⁶ fifteen years ago. Anatomic studies have shown that failure to free the fatty tissue from the deep fascia of the gluteal muscles for a sufficient distance from the margins of the wound is the main cause for difficulty in mobilizing the full thickness of the wound edges so that they can be brought together without tension. Dissection under

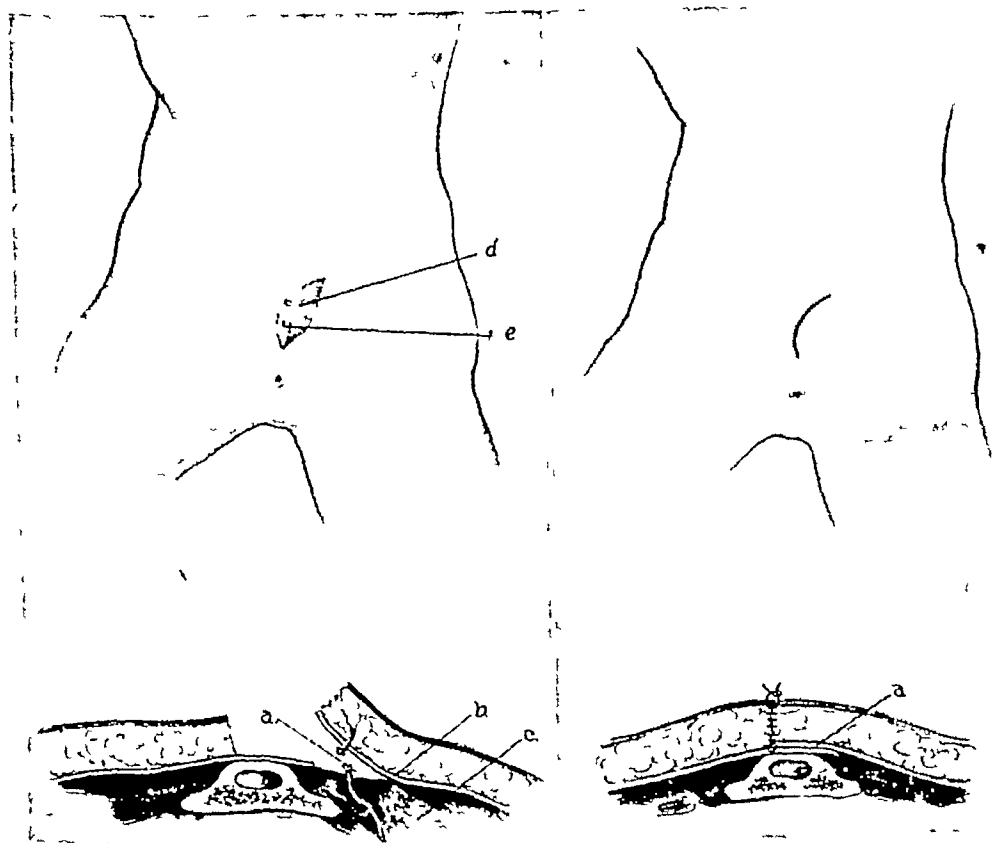


Fig 1

Fig 2

Fig 1—(a) Holding blood vessels perforating gluteal fascia and must be divided (b) gluteal fascia (c) gluteus maximus muscle (d) area undercut to provide flap of fascia skin and subcutaneous fat (e) pilonidal sinus

Fig 2—Postoperative (a) gluteal fascia.

these flaps shows that this is due to the holding action of blood vessels surrounded by dense fascia which perforate the gluteal fascia at right angles to enter the subcutaneous tissue at a distance of 3.5 to 5.0 cm from the midline (Fig 1). Only when these vessels are severed can full-thickness layers of skin and subcutaneous fat be completely mobilized. If undercutting laterally for this distance is accomplished through the usual vertical type of incision, ligation of the severed vessels is well nigh impossible. A curved incision (Fig 1) is, therefore, suggested which simplifies not only the mobilization of a flap, but also the hemostasis which is so essential to a good result.

PREOPERATIVE MANAGEMENT

In this series every effort has been made to control existing infection prior to any attempt at total excision with primary closure. Acute inflammation has been treated by incision and drainage and allowed to heal if this did not require too long a time. There was no hesitancy, however, in proceeding with excision in the presence of a clean granulating wound. All patients received sitz baths two or three times daily as an adjunct to cleansing of the operative area. It was felt that the absence of defecation during the healing phase was essential, not only to maintain cleanliness of the operative field, but to reduce to a minimum undue mobility and strain on the region of the buttocks such as occur in any attempted separation of the thighs during the act of defecation. To secure this end patients were given a purgative dose of castor oil and placed on a clear liquid diet forty-eight hours before operation. This diet was continued for seven to ten days postoperatively and was found to lead to satisfactory constipation during this period. Further prophylaxis in the prevention of infection was secured by the administration of sulfadiazine for two days preoperatively and seven to ten days postoperatively in a dosage by mouth sufficient to maintain a blood level between 4 and 10 mg per cent. It is felt that this precaution has definitely been advantageous because repeated studies have shown that the organisms responsible for infection usually belong to the streptococci and staphylococci strains which in turn are most readily controlled by this drug. No single instance of any postoperative infection of note has been encountered under this regime with the exception of one patient, who, because of sensitivity to the sulfonamides, did not have the advantage of the prophylactic administration of the drug.

No special preparation of the operative area was undertaken beyond the use of sitz baths. The region was shaved in the operating room and prepared by washing with green soap and water followed by alcohol, ether, and merthiolate. All operations were performed under low spinal anesthesia, a combination of 100 mg of novocain and 10 to 15 mg of pontocaine being administered in most instances. The addition of pontocaine prolongs the period of anesthesia for two to three hours. At this point it may be well to re-emphasize that the operation about to be described cannot be consummated in a short interval of time if one is to adhere strictly to the rules of gentleness, complete hemostasis, adequate release of the flap, and meticulous closure in layers with interrupted fine cotton sutures. Experience has shown that rarely can it be completed in less than ninety minutes and the more extensive cases require from two to three hours. While this may appear to be an unusually long and needless operative time, it is believed that the end results obtained, together with the short period of healing and the low rate of recurrences, thoroughly justify the added time consumed in performing the operation.

OPERATIVE TECHNIQUE

As represented in Fig 1, the incision commences at a distance of 5 to 7.5 cm from the midline slightly below the origin of the gluteus maximus muscle and curves downward and medially to the opposite side of the midline, keeping close

to the sinus tracts, through the complete thickness of the subcutaneous fatty tissue and underlying gluteal muscle fascia. The portion of the skin, subcutaneous tissue, and fascia represented by the shaded area in the diagram (Fig 1, *d*), is then dissected back as a full thickness flap. Over the sacrum it will be found relatively easy to follow a line of cleavage between the delicate, thin deep fascia over the bone and the diseased tissue which, in practically every instance, lies superficial to the former and is thus included in what now becomes the free border of the flap. As the dissection approaches the origin of the gluteus maximus muscle along the border of the sacrum, the dense fascia overlying the muscle is incised in a line paralleling the skin incision (Fig 1, *b*). Dissection then proceeds to lift up the dense gluteal fascia from the muscle so that it remains adherent to the fatty tissue and forms the deepest layer of the flap. In this stage of the operation lies the crux of the entire procedure, for the dense fibrous fasciculi attached to the gluteal fascia must be incised for a sufficient distance laterally to include division and ligation of the perforating vessels referred to previously in this report (Fig 1, *a*).

The diseased tissue which now lies in the inferior portion of the free border of the flap is excised by a second curved incision (Fig 1, *c*), care being taken to dissect as closely as possible to the cyst or sinus tracts, thereby sacrificing as little normal fatty tissue as possible. All bleeding points are ligated with fine ligatures. During the dissection and again before closure, the wound is repeatedly flushed with warm saline solution to remove all loose fat and clotted blood.

If this dissection has been adequate, it will then be found that the flap so outlined can easily be brought over to the other side of the incision to secure an anatomic layer closure. Three rows of fine sutures are placed, the deeper one uniting the free border of the gluteal fascia of the flap and the gluteal fascia of the opposite edge of the wound, a second layer in the subcutaneous fat, and the final layer in the skin (Fig 2). Care must be taken frequently to place more than two layers of buried sutures in the caudal portion of the wound in order to obliterate all dead space, and emphasis must again be placed on the use of fine bites in placing all of these sutures. Additional care must also be taken in placing the skin sutures in order to obtain accurate apposition of the skin edges and a small fine curved cutting needle has been found to be superior for this purpose. Any tendency to overlapping or turning in of the skin after suture will lead to delayed healing and the ready access of organisms into the wound. The resulting incision is so placed that it lies to one side of the midline thus avoiding maximum trauma (Fig 2).

No sulfonamide drugs are used in the wound, since experience has shown that they tend to increase exudation within the wound leading to some delay in healing. The operation is concluded by sprinkling sulfanilamide powder on the wound surface in an effort to create a dry, bacteriostatic dressing in an area which is otherwise prone to remain moist and infected. An ordinary gauze dressing is applied without pressure and the buttocks are held together by a larger layer of adhesive strapping designed to relieve tension on the wound during this healing phase.

POSTOPERATIVE ROUTINE

Patients remain in bed for a total of fourteen days and are not allowed to lie supine. The constipation routine is continued simply by allowing nothing but a diet of clear liquids until the tenth day at which time the mere addition of mineral oil and solid food produces an uncomplicated resumption of normal bowel habit. It might be anticipated that patients would lose considerable weight on such a regime but, on the contrary, on a liberal intake of fruit juices, jelly, and clear broth an adequate calorie intake is easily maintained. More-

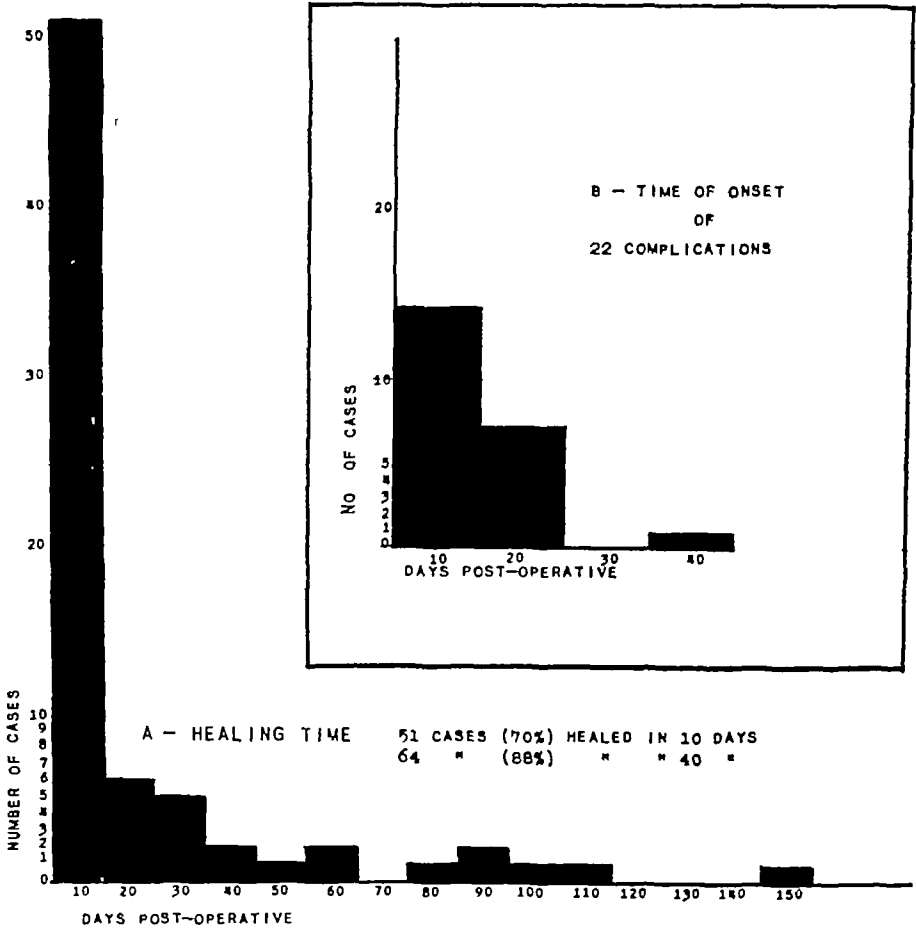


Chart 1—A, Showing healing time of the primary suture in seventy-three cases B depicting time of onset of postoperative complications

over, the patients have not complained, although it cannot be denied that they look forward with considerable relish to their first full meal. In any event this regime appears to be the only sure method of minimizing the gross soiling of the operative region which must, of necessity, occur during the act of defecation.

Sulfadiazine in doses of approximately 6 Gm daily is continued for seven days and has been found to maintain a blood level in the neighborhood of 5 mg per cent. In the series about to be reported there is no doubt in our minds

that this plan of chemotherapy has held postoperative infections to a minimum, since these are usually of the streptococci or staphylococci variety. The only serious major infection occurred in a patient who, because of the development of toxic reactions, could not be given the benefit of prophylaxis by any of the sulfonamides.

The dressing is usually changed on the fifth day, by which time considerable moisture has been found to collect between the gluteal folds, where this is excessive, sulfanilamide powder is frequently blown into the crease beneath the inferior portion of the dressing prior to the fifth day to render the skin as dry and bacteriostatic as possible. At the first dressing change the operative area is cleansed under strictly aseptic technique with alcohol, redusted liberally with sulfanilamide, and then redressed in the same manner as initially. The wound is not disturbed again until the sutures are removed on the tenth day when a similar dressing is reapplied until the fourteenth day. The patient is then allowed out of bed without any protective dressing unless some wound complication has developed in the interim.

After becoming ambulatory, patients are given sitz baths daily and instructed to keep the area scrupulously clean and to avoid any movement or exercise leading to undue abduction of the thighs or separation of the gluteal folds for one week. Patients are thus able to return to work after three weeks. That this is a safe and adequate interval for healing is attested by the fact that of the twenty-two complications in this series all but one had become manifest prior to the twenty-first postoperative day. (Chart 1, B)

RESULTS

This operative technique was introduced in April, 1943, and has been used by us to the exclusion of all others since September, 1943, at which time the superior results of the method became obvious. The desire to obtain a minimal scar and a thick mobile fat pad over the sacrum has been fully realized, and these results were not vitiated even in those wounds which developed complications. The results of seventy-three cases as summarized in Table I represent all the patients in whom the method described was used. Although various other

TABLE I HEALING TIME, COMPLICATION AND RECURRENCE RATES AFTER PRIMARY CLOSURE IN LAYERS (73 CASES)

	NUMBER OF CASES	PRIMARY HEALING IN 10 DAYS	WOUND COMPLICATIONS			AVERAGE DAYS TO HEAL ENTIRE GROUP	RECURRENCES	
			NUM BER	PER CENT	AVERAGE DAYS TO HEAL		NUMBER	PER CENT
1943								
Group A (April to Aug.)	27	19	8	29.6	31.1	16.2	2 (24)	8.3
Group B (Sept. to Oct.)	28	19	9	32.1	68.1	28.6	4 (27)	14.8
Group C (Nov. to Dec.)	18	13	5	27.7	45.6	19.9	—*—	—*
Totals	73	51	22	30.1	49.5	21.9	6†	11.7‡

*No follow-up on Group C but none have returned within three months of operation.

†Included among the 22 complications.

‡Calculated for 51 cases, 24 in Group A, 27 in Group B.

few developed prior to removal of the skin sutures (Chart 1) This is a clear indication that if the surgeon will keep these patients under close observation for three weeks, he will not fail to encounter all complications and, in all probability, all patients in whom recurrence might later develop The number of previous operations to which the patient had been subjected did not appear to affect the rate of primary healing unless there had been three or more In such an event the percentage of complications, healing time, and liability to recurrence were all increased

Analysis of the complications as to type, treatment, and healing time is provided in Table II The extrusion of cotton sutures or the development of a small superficial sinus containing a suture or a ligature was the commonest finding, accounting for 45 per cent (ten cases) of all failures in primary healing All healed in an average of thirty-seven days (Subsequently four of these ten patients returned with recurrences) The development of hematomas in six patients serves to re-emphasize the importance of hemostasis, which has been referred to previously Of these, four were successfully treated by repeated aspirations and two required open packing with an average healing time of thirty-nine days In three cases a mild separation of the skin (dehiscis only) occurred as a result of overlapping of the skin margins These patients were given no special treatment but required the astounding time of forty-seven days to heal, although in no instance was there any underlying sinus Gross infection occurred in only two patients and consisted in each instance of a small abscess in the subcutaneous tissue under the suture line containing about one-half ounce of frank pus These were packed open and required 90 and 100 days, each, to heal There was no single instance of spreading infection or deep infection under the flap in the entire series The one case listed as due to trauma was thought to have been caused by repeated willful scarification of a wound by the patient, first noted ten days after apparent primary healing had occurred Discovery of the cause led to rapid healing but only after 150 days had elapsed

TABLE II TYPES AND NUMBERS OF POSTOPERATIVE WOUND COMPLICATIONS WITH HEALING TIME AND RELATION TO RECURRENCE OF SINUS

TYPE OF COMPLICATION	NUMBER OF CASES	PER CENT OF TOTAL	TREATMENT	AVERAGE HEALING TIME (DAYS)	RECURRENCES		
					NUMBER	TREATMENT	AVERAGE HEALING TIME (DAYS)
Suture extrusion	10	45.4	10, removal of sutures	37.4	4	3, removal of infected sutures, 1, incision and drainage of abscess	50
Hematoma	6	27.2	2 packed open, 4 aspirated	39.1	1	Removal	28
Mild skin separation	3	13.6	Open healing	47.0	1		26
Gross infection	2	9.1	2 packed open	95.0	0		
Trauma	1	4.7	Open healing	150.0			
Totals	22	---	-----	49.5			

*Healing time for treatment of recurrences plus 30

hematoma was discharged as healed after open packing in eighty-seven days and returned one and one-half months later with a recurrent sinus which healed in twenty-eight days after removal of five sutures. One of the patients with skin separation was healed on the tenth day and subsequently returned with a sinus two months later, healing occurred in twenty-five days after the removal of a suture. It will be seen that of the six recurrences five were due to suture material lying in a small sinus. In no instance did this extend deep in the wound but was confined to the fatty subcutaneous tissue. All were treated by a small incision, removal of the offending suture, and open packing requiring an average of forty-four days to heal. It may be argued by some that these were not true recurrences and that this extra time required for healing should merely be added to the average healing time for the original complications recorded in Table II. Such an interpretation produces average healing times of 59.5 days

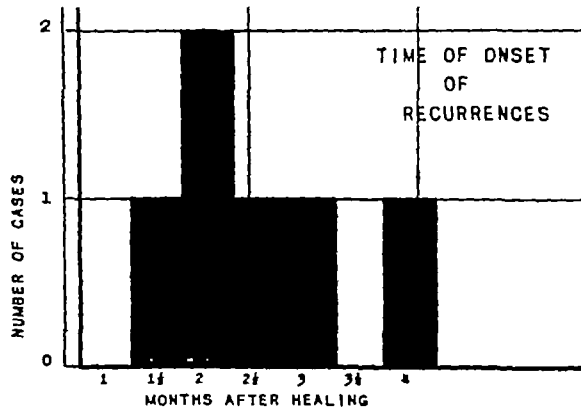


Chart 2—Showing time of onset of recurrences after healing

for the twenty-two complications and 24.9 days for the entire series of seventy-three patients. Coincidentally, this gives a recurrence rate of one case in the fifty-one patients in whom follow-up studies were available, a rate of 2 per cent. This, however, does not represent our opinion, we would be very pleased to accept the latter figures in the belief that such a low recurrence rate (2 per cent) would be a very desirable outcome of the operation in return for an additional three days' average healing time for the entire group.

SUMMARY

1. No attempt to review the literature completely or to include remarks on etiology or pathology has been made. For information on these aspects of the subject readers are referred to other recent publications, notably that of MacFee.²

2. A new operative technique designed to secure primary healing in primary closure after excision of pilonidal cyst and sinus is presented.

3. Included in the report of 73 patients receiving this treatment is an analysis of wound complications showing a rate of 30 per cent for the entire series.

4. In 70 per cent of patients, primary healing in the strictest sense was secured in ten days. The average healing time for the entire group was twenty-two days.

5. Follow-up examination of two-thirds of the patients shows a recurrence rate of 11.7 per cent.

REFERENCES

1. Bue, Louis A. Jeep Disease (Pilonidal Disease of Mechanized Warfare), *South M J* 37 103 109, 1944
2. MacFee, William F. Pilonidal Cysts and Sinuses, A Method of Wound Closure, *Ann Surg* 116 687 699, 1942
3. Mutschmann, G. A., and Mitchell, George A. A Treatment of Pilonidal Cysts and Sinuses, *J A M A* 124 30 31, 1944
4. McCutcheon, George T. Pilonidal Sinus, Application of Plastic Surgical Principles in a New Surgical Approach, *Ann Surg* 118 430-437, 1943
5. Shute, Frank C., Smith, Thomas E., Levine, Max, and Birch, John C. Pilonidal Cysts and Sinuses (Primary Closure), *Ann Surg* 118 706 716, 1943
6. Lahey, F. H. A Further Suggestion for the Operative Treatment of Pilonidal Sinuses, *Surg, Gynec & Obst* 54 521 523, 1932
7. Kooistra, H. P. Pilonidal Sinuses. Review of the Literature and Report of 350 Cases, *Am J Surg* 55 3 17, 1942
8. Rogers, H., and Hall, M. G. Pilonidal Sinus, Surgical Treatment and Pathologic Structure, *Arch Surg* 31 742 766, 1935
9. Kleckner, M. S. Pilonidal Sinus, Its Surgical Management, *Tr Am Proct Soc* 37 166 173, 1936
10. Scott, J. V. Pilonidal Cyst. The Local Use of Buffered Sulfanilamide in Primary Closure, *Ann Surg* 117 191 197, 1943
11. Swenson, S. A., Jr., Harkins, Henry N., and Groesbeck, Harry P. Pilonidal Sinus, *Am J Surg* 66 49, 1944
12. Felmus, L. B., Woods, C. C., and Strong, D. H. Pilonidal Cysts, *Arch Surg* 49 316, 320, 1944

CHOLECYSTODUODENOCOLIC MEMBRANES

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THE embryologic development of the peritoneum and its relation to the various abdominal organs is so complicated that many congenital abnormalities may exist after birth. Some of these abnormalities, such as those resulting in atresia or stenosis of bowel, are incompatible with life unless surgically corrected, while others may be only abnormalities of attachment and of position of viscera, and are mere anatomic curiosities. One of the more common anatomic peritoneal variations is the so-called cholecystoduodenocolic fold, which is essentially an extension of the normal hepatoduodenal ligament to include the gall bladder, second portion of the duodenum, and the hepatic flexure of the colon. This is a very common peritoneal abnormality, but its clinical significance has been the subject of some debate. The purpose of this paper is to attempt to evaluate its relation to upper abdominal symptoms, and also to indicate that it has been a very uncommon cause of serious symptoms in the patients seen at Strong Memorial and Rochester Municipal Hospitals. There are a few patients in whom the condition may cause symptoms which resemble gall bladder colic or duodenal or colonic obstruction, and who are relieved by surgical division of the bands. There are many more who never have symptoms from these bands, or in whom the bands are an incidental finding at exploratory laparotomy, and in these cases division of the bands does not relieve the symptoms.

The abnormal attachments between the gall bladder, liver, duodenum, and hepatic flexure of the colon were first noted by Virchow¹ in 1853, and were considered to be the result of a localized inflammatory process. In this country Morris² first described these folds of peritoneum in 1905, and described them as "cobwebs in the attic of the abdomen", he also considered them to be the result of chronic low-grade peritonitis. There was considerable discussion early in this century as to the etiology of these peritoneal bands, one group believing that they were the result of a localized peritonitis which may have started in fetal life, the other group believing that they were not inflammatory, but occurred as a result of excessive abnormal development of normal peritoneal folds. The evidence for and against the congenital development theory was evaluated by Harvey,³ in 1918, in an exhaustive paper on abnormal peritoneal attachments. He concluded that these membranes often developed in fetal life as a result of abnormal growth, and that the congenital type could definitely be differentiated from those resulting from inflammatory processes in the upper abdomen.

The abnormal peritoneal congenital attachments are most frequently seen about the gall bladder and duodenum (Bryant, 1922, 1923^{4, 5}). Bryant studied 297 consecutive autopsies from the standpoint of peritoneal variations, and found the so-called normal incidence as shown in Table I.

TABLE I

	MALE (PER CENT)	FEMALE (PER CENT)
Gall bladder to duodenum and transverse colon	25.6	24.8
Gall bladder to transverse colon	17.2	9.4
Gall bladder to duodenum	15.5	17.9
Appendix to peritoneum	15.0	5.9
Omentum to ascending and transverse colon	11.1	12.0
Ascending to transverse colon	10.6	5.9
Duodenum to peritoneum	6.7	10.3

These figures include both visceral adhesions and bands, so cannot be considered an accurate index of the congenital type. Harvey³ found an incidence of 18 per cent of "evstocolic folds" in 105 autopsies, and quoted the incidence recorded by other authors as shown in Table II. In addition to these series, 12 per cent occurrence was reported by Mayo⁶ in 150 cases.

TABLE II

NAME	NUMBER EXAMINED	PER CENT
Jonnesco	100	25
Addison	40	30
Mollison and Cameron	50	20
Buy	--	25
Bricon	89	15
Reid	20	30
Leveuf	50	28
Ssulow	145	23
Harvey	105	18

The relatively high frequency of occurrence suggests that it is erroneous perhaps, to consider these bands truly abnormal from the standpoint of pathologic physiology, even though they may be considered so anatomically. It is difficult to find adequate statistics to substantiate this statement, but the experiences of Whitaker⁷ are in accord with this thought. At autopsy, he found abnormal attachments of the gall bladder in 45 per cent of the cases. These did not show any evidence of inflammation, and he considered that they were of congenital origin. Whitaker also analyzed 100 consecutive cholecystectomies and found eighteen with abnormal attachments (the same incidence which occurred in Harvey's series), but only five of these bands were attached over the entire length of the gall bladder, and only one had definite duodenal compression. Only five of these cases had symptoms which seemed to be definitely related to the abnormal attachment, and rather severe abdominal symptoms, and improvement resulted from the removal of the band. There have been more than 1,200 cholecystectomies performed since the opening of Strong Memorial and Rochester hospitals. In the first eighteen cases have been found in which the bands have been considered due to abnormal congenital development. The first and second portions of the duodenum were removed in the first 18 cholecystectomies for the year 1940 were considered that the abnormal bands were the cause of the symptoms. The number had inferiority in the first 18.

little the possibility that the cholecystoduodenocolic fold or bands can and do cause definite symptoms, it merely indicates that while the condition may exist anatomically in 20 to 45 per cent of individuals, it causes deranged physiology in a much smaller number.

The cholecystoduodenocolic fold and its variations are a result of the development of the hepatogastric ligament⁸⁻¹⁰. In embryonic development the primitive gut is suspended from a dorsal mesogastrium throughout its entire length and by a ventral mesogastrium which extends only from the diaphragm to the first portion of the duodenum. The ventral mesogastrium becomes the hepatogastric ligament, and its caudal margin becomes the normal hepatoduodenal ligament with the portal vein, the common bile duct, and the hepatic artery developing between the two embryonic layers of peritoneum. Normally the ventral mesogastrium fades out in the peritoneum overlying the anterior wall of the duodenum, but occasionally there is a continuation of this layer over the gall bladder and medially over the duodenum to fuse with the peritoneum over the pancreas. This fold may also have extensive attachment to the liver in the region of the gall bladder. The colic portion of the membrane is probably formed as a result of the rotation of the large bowel, when, as it passes over the duodenum, the hepatic flexure or its mesocolon becomes attached to the caudal margin of the mesogastrium.

The normal attachment in this region is the hepatoduodenal ligament between the porta hepatis and the first part of the duodenum. The ampulla and fundus of the gall bladder are attached only to the liver bed, and are not involved directly in the hepatocolic ligament. The variations of the cholecystoduodenocolic fold may be multiple. There may be only a small band between the ampulla of the gall bladder and the duodenum, or there may be an extensive membrane attached throughout the entire length of the gall bladder, completely investing the descending portion of the duodenum and attached inferiorly to the hepatic flexure and to the right half of the transverse colon. The membrane may be broad and thin, or it may be narrow and quite thick. The vascularity of the membrane varies, but it usually has well-defined vessels coursing through it. These attachments may cause no visceral distortion, or they may cause distortion and/or narrowing of any portion of the gall bladder, particularly of the ampulla. The duodenum may be held very high beneath the porta hepatis with kinking of the curve of the first and second portions, or the descending portion may be constricted by pressure of the band. Occasionally the membrane may be so extensive that it causes deformity of the pyloric antrum of the stomach,¹⁰ and occasionally the colic portion causes constriction of the hepatic flexure. It is evident that the wide anatomic variations may cause symptoms referable to the gall bladder, duodenum, or colon.

Harris¹¹ in 1914 was the first in this country to call attention to the role of these congenital bands in producing abdominal symptoms. He reported six cases with partial duodenal obstruction as a result of compression by abnormal bands between the gall bladder, liver, and the second portion of the duodenum. Two of these patients also had symptoms referable to the gall bladder. Epi-

gastric discomfort varying from a sensation of heaviness to severe persistent pain was the outstanding symptom. All of the patients had disturbance of digestion characterized by epigastric distress two to three hours after eating, which was usually followed by nausea and emesis, with subsequent relief of pain. There was tenderness in the epigastrium, and gastric analysis indicated hyperchlorhydria. Harris found similar x-ray changes in his six patients. The first and second portions of the duodenum were dilated. The descending portion was fixed and usually displaced to the right side.

Following the report of Harris, many articles appeared in the literature during the next twenty years, but since then there has been very little written about this condition. These congenital bands were recognized by Coffey¹² in 1912, and described as one of the factors causing intestinal stasis in visceroptosis. There were many papers written about this time which were concerned with rather vague clinical entities such as ptosis of viscera, chronic appendicitis, chronic colitis, and periduodenitis, and congenital bands about the duodenum and gall bladder were blamed for a variety of abdominal complaints. The impression is gained from some of the writings that the congenital bands had very little to do with the various symptoms, and in many instances were merely something unusual in an otherwise negative exploratory laparotomy. There have been, however, a number of articles dealing with a careful analysis of the symptoms which these membranes may cause, and Homans¹⁴ in 1916, first emphasized their similarity to gall bladder disease and/or to duodenal ulcer. It is unnecessary to attempt a summary of all that has been written on this subject, but the usual clinical picture can be summarized from various papers which will be referred to as they are encountered.

The main symptom is usually pain located in the mid-epigastrium or in the right upper quadrant. The pain is usually inconstant, and in many patients has been present for years with a gradual increase both in severity and in the frequency of exacerbations. The symptoms may very closely simulate those of gallstone colic, with radiation of pain around the costal margin, nausea and emesis, and subsequent periods of complete freedom from symptoms. There may be intolerance of fatty foods.¹³ Another group of patients have symptoms resembling duodenal ulcer, with gnawing epigastric pain,¹⁴⁻¹⁷ but the pain tends to be constant rather than intermittent, is partially relieved by emesis, and increased rather than relieved by food intake. The vomiting has been explained on the basis of duodenal irritation and partial obstruction rather than of pylorospasm.¹⁸ The bands may, however, cause complete duodenal obstruction, as in the three children reported by Neff and Haden¹⁹ who died of alkalosis. A very high percentage of the patients reported have had chronic dyspepsia for a number of years, characterized by gaseous indigestion, sour stomach, asthenia, etc. The gastric acidity varies considerably, and has not been helpful in making the diagnosis.

The roentgenologic findings are not pathognomonic, but barium study of the gastrointestinal tract is often helpful. The typical deformity as described by Taylor,¹⁷ and by Kantor,¹⁸ is high fixation of the duodenum, usually asso-

ciated with a dilated ptotic stomach. The cap and first portion of the duodenum may be rotated more posteriorly than normally, and there is sharp angulation between the first and second portions of the duodenum. Simultaneous visualization of the gall bladder and duodenum has been tried by Meyers and Bloom²⁰ with very little help in evaluating the condition, but it was possible to make a preoperative diagnosis by this method in one of our cases. It has been emphasized repeatedly in the literature that in many instances deformities of the duodenum or gall bladder may be seen by x-ray examination, but they are of no clinical significance unless there are associated clinical symptoms.

Since the opening of Strong Memorial and Rochester Municipal Hospitals in 1926 there have been only eighteen cases in which congenital bands about the gall bladder and duodenum of the cholecystoduodenocolic type have been considered to be the cause of the patient's upper abdominal symptoms, and which have been proved by laparotomy. This excludes all those cases in which the bands may have been found as an incidental finding, but where other definite organic disease, which was considered the cause of the symptoms, was present. Thus, all patients having acute or chronic inflammation of the gall bladder, cholesterosis, gallstones, duodenal ulcer or gastric ulcer were excluded from the series. Only those patients having no pathologic evidence of cholecystitis and no evidence of inflammatory changes about the gall bladder and duodenum were included.

There have been more than 1,200 cholecystectomies performed for various abnormalities of the gall bladder and biliary tract, so the actual incidence of the bands causing symptoms which simulate gall bladder disease is very small. The operative notes of 100 consecutive cholecystectomies in 1940 were selected as a representative sample, and were analyzed from the standpoint of congenital bands and inflammatory adhesions. There were seven cases (7 per cent) in which congenital bands were present and associated with acute cholecystitis, stones, or other gall bladder disease. This incidence of 7 per cent is distinctly less than the reported incidence in many series. The total number studied may not have been large enough to be representative, but it serves to emphasize that the presence of the bands does not necessarily predispose the individual to gall bladder disease. Of the 100 patients, 50 per cent had adhesions about the gall bladder which were definitely of inflammatory origin.

The eighteen cases of congenital bands fall into three groups in regard to the type of symptoms. Six had symptoms suggestive of gall bladder disease. In all of these there were intermittent attacks of pain in the right upper quadrant which in four of the six were colicky in nature, radiated around the costal margin to the back, and were associated with nausea and emesis. Two of these patients had intolerance of fatty foods. The pain did not, however, subside completely between the attacks, as is usual with gallstone colic. Seven had ulcer-like symptoms, which also suggested partial duodenal obstruction. The pain was located in the epigastrium, was usually increased by food intake, and was frequently relieved by vomiting. The pain was usually persistent with occasional sharp exacerbations, but did not have the typical periodicity or food relief of

duodenal ulcer Five of the seven patients with ulcerlike symptoms had vomiting, in three it occurred one and one-half to two hours after food intake with resultant relief of symptoms, in the other two the vomiting did not follow a definite pattern The third group consisted of five patients whose pain was upper abdominal but was vague and indefinite and whose symptoms could not be classified as ulcerlike or gall bladderlike

The average age of patients in this series at the time of operation was 40.5 years, the oldest patient was 62 years, the youngest, 26 years The average duration of symptoms was five years, the shortest seven months, and the longest twenty-three years The two patients who were not improved by operation were both 26 years of age The total duration of symptoms did not bear a direct relation to curability, but all of the patients who were considered cured had had exacerbations of symptoms from four months to one year before operation Two had had symptoms for twenty and for twenty-three years, which increased in intensity during the four months before operation None of the patients gave a history of having had repeated gastrointestinal upsets during childhood, as was emphasized by Taylor¹⁷

All eighteen patients had nausea which was either persistent or occurred with the attacks, and ten had repeated episodes of vomiting The appetite was persistently poor in four patients, and in the gall bladder type there was anorexia with the attacks of pain All patients had dyspepsia which differed with individuals, but it was described most commonly as gaseous distress after meals, a heavy sensation in the upper abdomen, and sour eructations Constipation was not characteristic of the group None of the eighteen patients had had jaundice or acholic stools Eleven patients gave a history of recent weight loss, one had lost thirty-five pounds in one year

The only physical sign usually present was deep tenderness in the right upper quadrant or epigastrium Three of the patients were seen during repeated attacks simulating gall bladder colic, and these had marked tenderness in the right upper quadrant with muscle spasm and rebound pain The laboratory data, except for the x-ray findings, were of very little value in the diagnosis Anemia has not been characteristic of the condition Gastric analysis was performed on eight patients Three had normal acidity, and one hyperchlorhydria Three had no fasting free hydrochloric acid, but did respond to alcohol or histamine One had no free acid with either alcohol or histamine, and this patient was thought to have carcinoma of the stomach preoperatively

The x-ray findings were not always diagnostic, and the so-called typical deformity of the duodenum, so frequently mentioned in the literature, was not observed consistently The barium studies were interpreted as showing abnormalities of the duodenum in seven cases, and these are listed in Table III A typical deformity of the duodenum is shown in Fig 5 A preoperative diagnosis of congenital bands was made in five cases, chronic cholecystitis in eight, duodenal ulcer in two, and tumor of the ampulla of Vater, chronic appendicitis, and questionable carcinoma of the hepatic flexure of the colon, in one each The operative procedure was cholecystectomy and division of the bands in eight cases

TABLE III

CASE NUMBER	PREOPERATIVE DIAGNOSIS	ROENTGENOLOGIC FINDINGS
1	Obstruction of duodenum from congenital bands	Widening of duodenal loop 1½ cm beyond cap
2	Chronic cholecystitis and cholelithiasis	Roentgenograms reported cholelithiasis (taken outside)
3	Chronic cholecystitis and cholelithiasis	Irregular dilatation, second portion of duodenum, cholecystogram negative
4	Chronic cholecystitis, question of cholelithiasis	Cholecystogram and gastrointestinal series negative
5	Chronic cholecystitis	Large atonic gall bladder with poor emptying
6	Pericholecystic membrane	Irregularity of duodenum in second portion, cholecystogram negative
7	Question of pericholecystic membrane, question of tumor of ampulla of Vater	Localized narrowing of descending loop of duodenum with stasis
8	Duodenal ulcer	Delayed emptying of stomach, no duodenal deformity
9	Duodenal ulcer	Irregular cap, pylorospasm
10	Carcinoma of stomach	Constant filling defect of pyloric antrum on lesser curvature
11	Duodenal colic band	Constriction of colon at hepatic flexure, angulation and narrowing of descending portion of duodenum
12	Chronic cholecystitis	Large atonic gall bladder, no stones
13	Chronic cholecystitis	Poorly filling gall bladder, no stones
14	Recurrent appendicitis	No roentgenograms
15	Question of chronic cholecystitis, question of duodenal obstruction	Delay of barium in second and third portions of duodenum, cholecystogram negative
16	Question of carcinoma of stomach	Narrow prepyloric area of stomach
17	Question of chronic cholecystitis, question of obstruction of ascending colon	Large gall bladder with poor emptying, high hepatic flexure with narrowing
18	Cholecystoduodenocolic membrane	Fixation of gall bladder, duodenum, and hepatic flexure of colon

TABLE IV

	CURED	IMPROVED	NOT IMPROVED
Pain simulating gall bladder disease (colic)	6	0	0
Ulcerlike symptoms	5	2	0
Indefinite pain	2	1	2
Total	13	3	2

and division of the bands without cholecystectomy in ten cases. One of these ten also had a Heineke-Mikulicz pyloroplasty because of definite narrowing of the duodenum as a result of the pressure from the band. Incidental appendectomy was performed in seven.

The type of congenital bands found at operation varied considerably. Figs 1 and 2 are illustrations of the most extensive type seen, and this type was most commonly encountered. This type is attached over the entire gall bladder and spreads out, involving the duodenum, the hepatic flexure, and the proximal portion of the transverse colon. When the abdomen is opened, the band is found to obscure completely the gall bladder and duodenum. As the band is dissected free, the duodenum is found to be attached very close to the ampulla of the gall

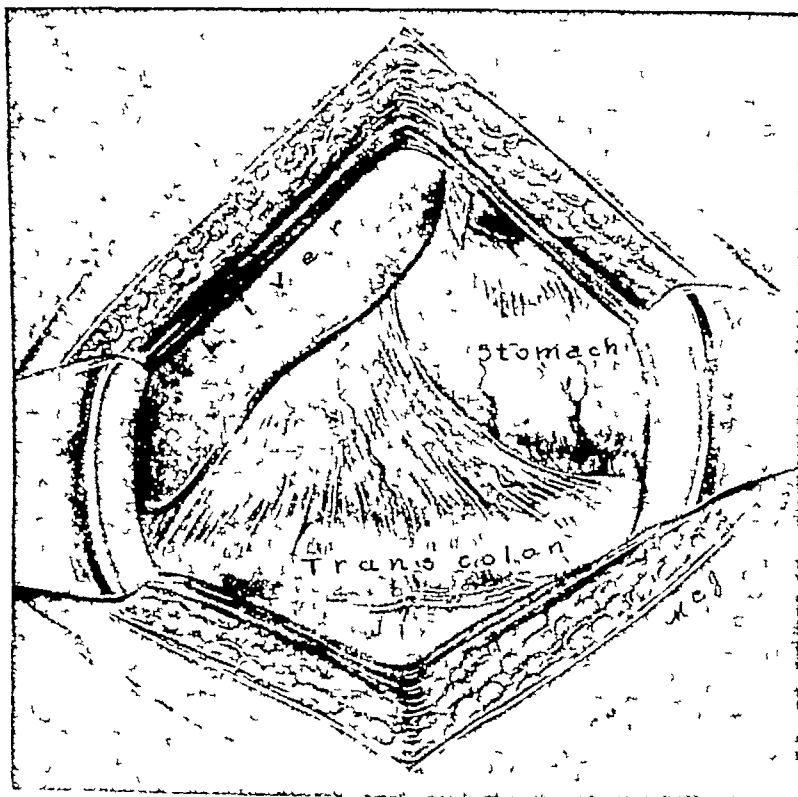


Fig 1—Appearance of cholecystoduodenocolic membrane on opening the abdomen

bladder, and is pulled upward and rotated counterclockwise by the band. The colon may be narrowed by the band as it extends over the bowel and fades off in the omentum. In one case a small band between the gall bladder and duodenum without a colic component caused nearly right angle distortion of the ampulla of the gall bladder, thus causing obstruction. In another patient a band was attached to the lesser curvature of the stomach just at the pylorus which had caused a filling defect on barium study, suggesting carcinoma.

Operative Results—The patients in this series have been followed from two to twenty years. Thirteen of the eighteen patients are considered cured, three

are improved, and two are not improved. Those who have been considered cured have been free of pain and free of the episodes of nausea and emesis. Those who are considered improved still have some vague abdominal symptoms, pain has been relieved, but they still have indigestion with occasional nausea and emesis. The two patients who were not improved had symptoms for eight and two years, the three only improved had symptoms nine months, three years, and four years. The patients who were not cured had no other demonstrable organic cause of complaints. An analysis of the cases shows very strikingly that those patients who had severe pain, either persistent or in periodic attacks, were the ones benefited by the operation. The individuals with equivocal symptoms had equivocal results, as illustrated in Table IV.

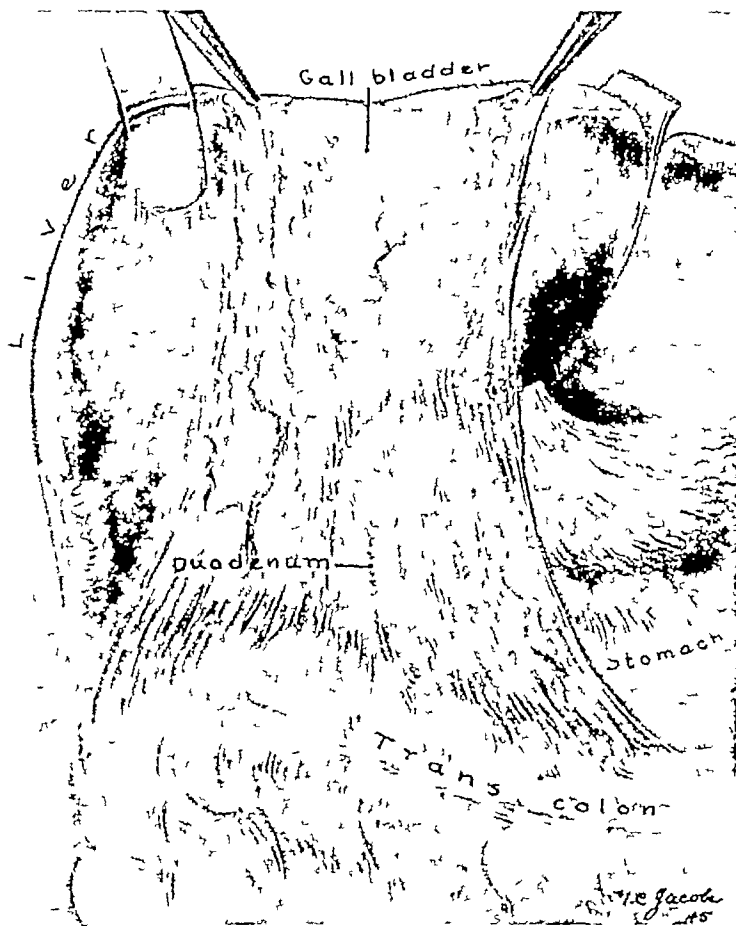


Fig 2—Cholecystoduodenocolic membrane after partial mobilization.

It should be emphasized that many of these cases had been studied repeatedly either by a local physician or in the hospital before operation was advised. All the patients had had a trial of conservative medical therapy. The following case reports are included to illustrate typical examples.

CASE REPORTS

Symptoms Resembling Duodenal Ulcer

H B (S.M.H. No 186710) was a 41 year old white married man who had first developed epigastric pain at the age of 18 years. The pain was gnawing in character, and at first was relieved by the ingestion of food. A diagnosis of duodenal ulcer was made, and with ulcer therapy the symptoms subsided. He had several exacerbations of the pain during the next twenty years, and these often occurred at times of mental stress. For the six months prior to admission he had had progressive anorexia, frequent emesis one to two hours after meals, and a weight loss of twenty five pounds. He was referred to Strong Memorial Hospital with a diagnosis of duodenal ulcer with obstruction.

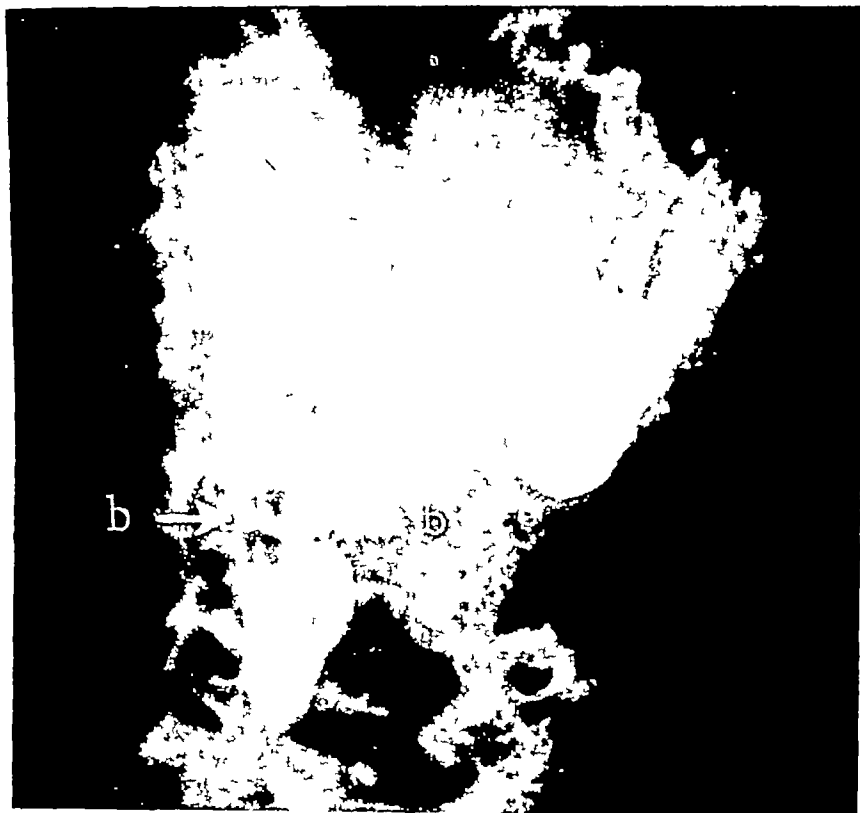


Fig 3—Narrowing of descending loop of duodenum associated with cholecystoduodenocolic membrane

Examination revealed a well developed, thin man of 41 years, appearing chronically ill. The only positive physical findings were eczema of the hands and deep tenderness in the epigastrium. There was no palpable mass.

Laboratory Findings Red blood count, 5,800,000, hemoglobin, 16 Gm., white blood count, 11,200 with normal differential. Urine and stool were negative, Wassermann was negative. Nonprotein nitrogen was 33 mg per cent, icteric index, 3, total plasma protein, 6.7 Gm. per cent, blood chlorides, 100 meq. Gastric analysis showed 160 c.c. residue with free acid (amount not recorded).

X ray Examination (Figs 3 and 4)—The descending loop of the duodenum showed a persistent area of narrowing. The loop was dilated above and below this area, and was closely adherent to the hepatic flexure of the colon.

Operation—A congenital cholecystoduodenocolic membrane was found, as illustrated (Fig 2). This had caused definite distortion of the duodenum and accounted for the x-ray appearance. There was no evidence of a duodenal ulcer. The membrane was divided and the duodenum mobilized to its normal position. The raw areas were peritonized and the appendix was removed. Cholecystectomy was not done.

The patient had an uneventful convalescence, and has had no recurrence of the symptoms.



Fig 4—Same as Fig 3

Symptoms Resembling Gall Bladder Disease

S J (S.A.M.H. No 176100) was a 41-year-old white married woman who for eight years had had intermittent attacks of severe colicky right upper quadrant pain radiating around the right costal margin to the back and scapular region. She had nausea, anorexia, and emesis with each of these attacks, which usually lasted one or two days. Between the attacks she was quite well, appetite was good, and she did not have fatty food intolerance. During the four months prior to admission she had had constant right upper quadrant pain with colicky exacerbations, almost constant nausea, anorexia, and weight loss of about twenty pounds. The stools had been normal. There was no history of jaundice.

Past History—The patient had had a right-sided pyelitis one year before, but the urinary infection had subsided with therapy. She had had a left radical mastectomy for carcinoma of the breast three years previously.

Examination—Temperature was 37° C, pulse was 80, respirations were 20, blood pressure was 126/70. The patient was a well-developed, moderately obese woman of 41 years.

appearing acutely ill. There was no jaundice. The positive physical findings included a well healed left mastectomy scar with no evidence of local recurrence of the tumor, the abdomen was moderately obese and not distended. There was exquisite tenderness in the right upper quadrant with localized muscle spasm and local rebound tenderness. Compression of the costal margin elicited pain.

Laboratory Data Hemoglobin, 13 Gm, white blood count, 10,000, urine, occasional white blood cells. Wassermann was negative, nonprotein nitrogen, 32 mg per cent, icteric index, 0, total protein, 7.3 Gm per cent, albumin, 3.9, globulin, 3.4.



Fig 5—Angulation of duodenum due to cholecystoduodenocolic membrane.

X ray Examination—The oral cholecystogram showed rather poor filling of the gall bladder, but there was no evidence of calculi. The gastrointestinal series showed only tenderness over the second portion of the duodenum, and the barium enema was negative.

Because of the possibility that the recent pain might be due to metastatic carcinoma from the breast, the patient was treated conservatively with atropine, bile salts, and a low fat, smooth diet. She improved slightly, but returned in three months with the same type of severe pain. The physical findings were unchanged. The x ray studies were repeated, and by chance the patient was given the dye for a cholecystogram on the day prior to a gastrointestinal series. The following day the gall bladder was filled with dye, there was still barium in the colon from a barium enema, and after barium had been ingested by mouth, the duodenum, gall bladder, and colon could be visualized. All three structures moved en masse, and could

not be separated by abdominal manipulation, which suggested the diagnosis of a congenital cholecystoduodenocolic membrane. At operation a broad membrane, which caused torsion of the ampulla of the gall bladder and distortion of the duodenum, was found. The bands were divided, and cholecystectomy was performed. The gall bladder contained no stones and there was no microscopic evidence of acute or chronic inflammation. The patient has been followed for four years since the operation, she has had no recurrence of symptoms and no evidence of metastases from the carcinoma of the breast.

No Relief of Symptoms

J. L. (S. M. H. No. 163751) was a 26 year old single white man who complained of intermittent epigastric and right upper quadrant pain of eight years' duration. At times the pain was severe, but it did not follow any pattern with relation to meals. Associated with the episodes of pain he had nausea, anorexia, and generalized weakness. He had no intolerance of fats, no constipation, and no weight loss. The patient appeared quite nervous and somewhat emotionally unstable.

The physical examination was essentially negative except for vague deep tenderness in the epigastrium. The laboratory examinations were all within normal limits. The gastrointestinal series was negative except for an irregular appearance of the second portion of the duodenum and an area of persistent narrowing $1\frac{1}{2}$ inches beyond the cap.

The patient was discharged following a period of study, but returned one month later, and an exploratory laparotomy was performed because of persistence of the symptoms. The only positive finding at operation was a cholecystoduodenocolic membrane, which was divided. The patient improved for a few months, but has had a recurrence of the symptoms. It is probable that the symptoms are on a psychogenic basis, and the congenital membrane was not the cause of the trouble.

DISCUSSION

Congenital peritoneal bands about the gall bladder, duodenum, and colon are quite common, but they cause symptoms in relatively few individuals. The symptoms which may occur as a result of the bands most commonly resemble those of gall bladder disease, of duodenal irritation, or of obstruction. The symptoms are usually not completely typical of either of these conditions, and unless there is definite abnormality of the duodenum by x-ray examination, the diagnosis is frequently very difficult. It should be emphasized that the mere diagnosis of bands by x-ray examination is not sufficient reason for operation unless the patient's symptoms and clinical course point definitely toward the gall bladder or duodenum. The reason the bands cause symptoms is not always clear, but it is usually because of mechanical partial obstruction, either of the ampulla of the gall bladder or of the duodenum. The patients with severe pain and persistent symptoms have been, in our experience, relieved by operation. Those patients who have less definite symptoms, that is, those who have had only indigestion and indefinite pain have a much poorer chance of being helped by division of the bands.

The diagnosis of these congenital bands should not be made until the patient has been studied carefully to rule out the more common causes of upper abdominal pain, such as cholelithiasis, duodenal ulcer, etc. The operative treatment should not be undertaken until a careful medical regimen has failed to relieve the symptoms. Simple division of the bands with reperitonization of the raw edges is all that need be done at operation. In those patients whose symptoms have resembled gall bladder disease, cholecystectomy has often been performed, but the patients who had cholecystectomy did not have a higher per-

centage of relief of symptoms than did those with simple division of the bands. Homans originally advised that some type of plastic procedure be performed on the duodenum in those cases where definite narrowing was present. Pyloroplasty was considered necessary only once in our series. The operative failures are usually due to incorrect evaluation of the cause of the patient's symptoms rather than to inadequate operative procedures. It would probably be more nearly correct to say that too many of these patients have been operated upon, and the proper clinical attitude should be one of skepticism unless the clinical picture is very definite.

CONCLUSION

1 Congenital peritoneal membranes about the duodenum, gall bladder, and colon (the cholecystoduodenocolic membrane) occur in 18 per cent or more of individuals, but cause symptoms of upper abdominal pain in a very small percentage. Only eighteen cases have been encountered at the Strong Memorial and Rochester Municipal Hospitals in which these bands have been considered the cause of symptoms.

2 The symptoms caused by these congenital membranes resemble gall bladder disease and/or duodenal ulcer.

3 Operative intervention is justified only in selected cases, and those patients having severe pain are most benefited.

REFERENCES

- 1 Virchow, R. Historisches, Kritisches, und Positives zur Lehre der Unterleibsaffektionen, Arch f path Anat 5 281, 1853
- 2 Morris, R. T. Gall Spider Cases, Am Med 10 95, 1905
- 3 Harvey, S. C. Congenital Variations in the Peritoneal Relations of the Ascending Colon, Caecum, Appendix, and Terminal Ileum, Ann Surg 67 641, 1918
- 4 Bryant, John. Visceral Adhesions and Bands. Normal Incidence, Am J M Sc 163 75, 1922
- 5 Bryant, John. Visceral Adhesions and Bands. Normal Incidence, Am J M Sc 165 111, 1923
- 6 Mayo, W. J. Some of the Disputed Problems Associated With Surgery of the Large Intestine, Am J M Sc 145 157, 1913
- 7 Whitaker, L. R. Congenital Adhesions of the Gall Bladder, Ann Int Med. 11 379, 1937
- 8 Huntington, G. S. The Anatomy of the Human Peritoneum and the Abdominal Cavity, Philadelphia, 1903, Lea Brothers and Co
- 9 Cunningham, D. J. Textbook of Anatomy, New York, 1928, William Wood & Co
- 10 Nagel, G. W. The Etiology and Importance of the Cystico Duodeno Colic Fold, Surg, Gynec & Obst 37 365, 1923
- 11 Harris, M. L. Constrictions of the Duodenum Due to Abnormal Folds of the Anterior Mesogastrium, J. A. M. A 62 1211, 1914.
- 12 Coffey, R. C. The Principles Underlying the Surgical Treatment of Gastro Intestinal Stasis Due to Causes Other Than Stricture or Ulcerative Conditions, Surg, Gynec & Obst 15 365, 1912
- 13 Duval, P., Roux, J. C., and B  cl  re, H. The Duodenum. Medical, Radiologic, and Surgical Studies, St. Louis, 1928, C. V. Mosby Company
- 14 Homans, John. A Study of the Symptoms and Treatment of Congenital Transduodenal Bands, Boston M. & S. J 175 665, 1916
- 15 Niles, W. L. Congenital Fixation of Duodenum, Am J M Sc 169 328, 1925
- 16 Solem, G. O. Duodenal Obstruction Due to Cholecysto Duodeno Colic Bands, M. Clin North America 9 1423, 1926
- 17 Taylor, A. S. Anomalous Abdominal Membranes, Ann Surg 75 513, 1922
- 18 Kantor, J. L. Common Anomalies of Duodenum and Colon, J. A. M. A 97 1785, 1931
- 19 Neff, F. C., and Haden, R. L. Congenital Transduodenal Bands, Am J Dis Child 30 82, 1925
- 20 Meyers, S. L., and Bloom, A. R. Periduodenitis and Pericholecystitis—An Anatomic and Clinical and Roentgen Study of Adhesions in the Upper Right Quadrant, Arch Int Med 51 558, 1933

CLINICAL MANIFESTATIONS OF LUMBAR SPINAL ARACHNOIDITIS

A REPORT OF THIRTEEN CASES

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THE term spinal arachnoiditis has been loosely used in the past to describe a series of poorly understood aseptic inflammatory processes of the leptomeninges. The clinical manifestations of arachnoiditis are obscured by the factors listed here. Failure to recognize these variants has resulted in fathomless confusion.

1 The local pathologic manifestations of arachnoiditis may vary considerably. Descriptions of the diffuse, disseminated, circumscribed, cystic, and adhesive forms as well as of many other less common subdivisions are available.

2 It may occur at various levels and to different degrees initiating widely differing clinical changes. It is probable that most of the literature on the subject concerns only the more advanced forms of the disease, and that milder manifestations are common yet go unrecognized.

3 The described etiologic factors initiating arachnoiditis are legion. While a primary form is possible, it seems likely that it is usually secondary to other processes which in themselves produce clinical variation in symptoms or signs.

4 There is great individual variation in the clinical course of patients with arachnoiditis.

5 The various forms of spinal arachnoiditis often produce clinical manifestations which closely simulate those of another poorly understood group of conditions including Guillain-Barré syndrome, Landry's ascending paralysis, radiculomyelitis, polyradiculitis.

It is, however, well documented that aseptic arachnoidal inflammation may commonly be associated with other primary diseases of the spine or spinal cord. The lumbar spine is particularly predisposed to injury and, in recent years, stress has been placed on intervertebral disc abnormalities as the source of a large percentage of previously unexplained low back symptoms. The possibility of intradural inflammatory changes complicating these low back abnormalities has been dealt with lightly, but sporadic reports on spinal arachnoiditis associated with protruded intervertebral disc are available.

For this reason, an evaluation was undertaken of patients with spinal arachnoiditis in the lumbar region. Of approximately 200 patients explored for protruded intervertebral disc at this hospital, thirteen were found to have local arachnoiditis. Eight of these patients had protruded intervertebral discs. The remaining five were early cases, and protrusion may have been overlooked. They presented, however, clinical findings indistinguishable from those seen with dis-

cogenetic disease and are included here as examples of arachnoiditis probably on that basis. Intradural exploration was infrequently performed so it is probable that arachnoiditis may have been present in a much higher percentage of the cases. In all thirteen cases of this series, however, intradural verification was obtained and, in three of these, histologic sections of the arachnoid were made. An example is included in Fig. 3.

The results seem to indicate that intradural arachnoidal irritation is fairly common and may be frequently associated with intervertebral disc disease. The term localized spinal arachnoiditis is here used to indicate what appears to be an intrathecal aseptic inflammatory process adjacent to and resulting from intervertebral disc disease in the lumbar spine. The term inflammation is used to indicate arachnoid hyperplasia with subsequent thickening and formation of collagenous adhesions.

CLINICAL DATA

Etiology—In this series, there were nine men and four women ranging in age from 25 to 62 years. There were only four who gave a history of significant trauma, but twelve gave a history of chronic backache of six months to thirty years' duration. The onset of acute symptoms occurred less than two months before hospital admission in eleven, and less than two weeks before admission in six patients.

At this hospital, spinal arachnoiditis has been verified at operation in eighteen cases. In an additional nine cases it has been strongly suspected by virtue of abnormal spinal fluid and myelographic changes supplementing compatible clinical findings. The incidence of lumbar arachnoiditis in this series would then be 46 per cent, a figure which is at variance with the usually described high incidence of dorsal involvement in this disease.

Clinical Description—The clinical findings in this group of patients were essentially similar, but there were rather marked differences in the degree and extent of the history and physical changes encountered.

History—In most cases, there was an acute onset or increase of symptoms superimposed on a previous prolonged history of chronic or intermittent backache. Pain radiating in either or both lower extremities was present in all patients except one, where it was localized to the left sacroiliac region. The pain was variously reported as "shooting," "burning," "cramping," and "aching." Some form of paresthesia was present in eleven cases and weakness in the legs was reported in five cases. Muscular twitching was present in four cases. In the more advanced cases, sphincter disturbances (four patients) and marked muscular weakness or paralysis (four patients) were reported.

The reported symptoms were somewhat patchy and diffuse, being bilateral in seven patients. In five patients, pain or paresthesia was present to some degree in one upper extremity as well as in the legs.

Physical Findings—The findings on physical examination varied from almost nothing to evidence of advanced cauda equina compression. Some degree of stiffness, limitation of motion, spasm, and tenderness in the back were reported in ten patients and sciatic stress tests were positive in the same number.

of cases. Muscular weakness or atrophy was present in nine patients amounting to marked weakness or paralysis usually in the feet in three instances. Objective sensory changes were noted in twelve cases, but in only six was the sensory change localized to one leg in the distribution of a single nerve root. Reflex changes were present in twelve cases, but a single reflex was altered in only six patients. Of the remaining cases, two or three reflexes in the lower extremities were bilaterally altered in five, and both ankle jerk and knee jerk unilaterally diminished in one instance.

To evaluate the degree of advancement of physical changes, the patients were divided into three groups. One patient, considered to have slight physical evidence of arachnoiditis, showed no reflex changes, minimal back abnormalities, equivocal sensory changes, and was not acutely ill. Four patients with advanced changes were acutely ill, had bilateral weakness or paralysis in the legs, marked sensory changes, and sphincter abnormalities. The remaining eight patients considered to show moderate changes had definite neurologic abnormalities consisting of reflex and sensory abnormalities and alteration of back and leg function.

Subarachnoid Studies—The results of the subarachnoid studies are listed in Table I. Spinal fluid protein and mechanics were reported in eight cases. Increase in protein from 40 to 630 mg per cent was present in six cases and manometric block in one case. Subsequent readings were done in two cases, three and seven days after the initial spinal puncture, showing drops from 50 to 7 mg per cent in one and from 55 to 30 mg per cent in the second. In one instance, the puncture was done below a complete block (protein 630 mg per cent) and in one case by cisternal approach (protein 20).

Myelograms—Contrast subarachnoid studies were done in all cases, usually with Pantopaque. Complete block was present in seven cases, and localized abnormality, usually associated with a ragged appearance for a segment above

TABLE I SUBARACHNOID STUDIES

PATIENT	LEVEL	ACUTE SYMPTOMS	LUMBAR PUNCTURE						MYELO GRAM
			FIRST			SECOND			
			D A O	P	B	D A O	P	B	
F S	L4	3 days	1 wk	80					Block L3
M D	L3	3 wk	4 wk	630	L3				Block L2
E R	L4	2 wk	6 wk						Block L4
J G	L4	2 wk	3 wk	60					Block L4
J B	L3	2 wk	3 wk						Defect L4
C C	L4	12 wk	14 wk						Defect L4
J H	L4	8 wk	8 wk	40					Block L4
S S	L5	7 mo	7 mo	20 (cisternal)					Block L5
A H	L4	2 yr	2 yr	25		2½ yr	20		Defect L4
R A	L3	5 wk	5 wk						Defect L3
B O	L3	3 hr	3 days	50		10 days	7		Defect L4
J C	L4	2 wk	2½ wk	55		4 wk	30		Defect L4
F L	L4	6 wk	8 wk	25					Block L4

D A O Days after onset.

P Protein

B Manometric block

or below the defect, noted in the remaining six cases (Fig 1) Myelograms were repeated in two cases, four weeks and one year after operation. In one patient a simple defect resulting from an extruded nucleus pulposus was originally seen. Two weeks after operation, rapid increase in symptoms occurred, and a complete block was found on myelography. At operation, extensive local-

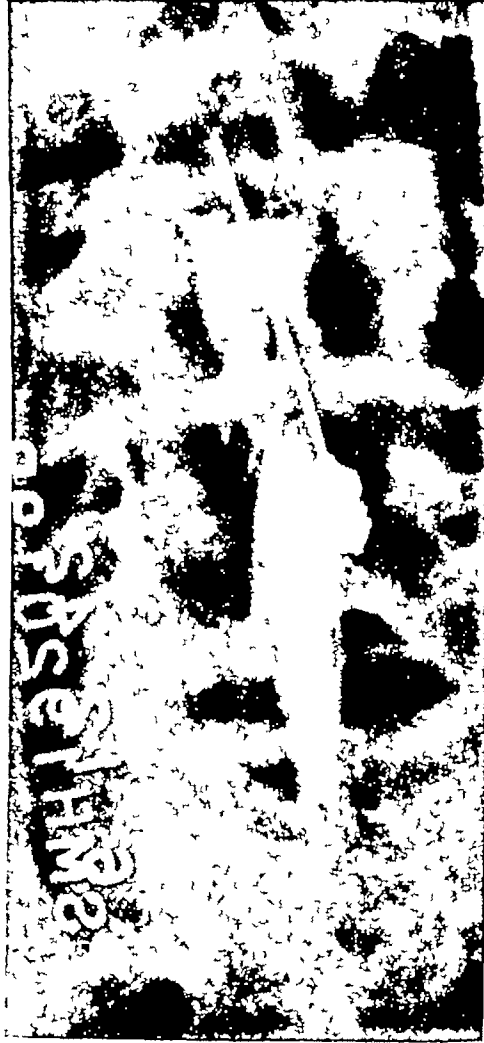


Fig 1 (Case 1) —Myelogram showing defect with associated ragged appearance to opaque column frequently seen in localized arachnoiditis

ized arachnoiditis without extradural compression was encountered (Fig 2). The other patient showed little change on repeat subarachnoid visualization one year following myelography and removal of disc protrusion, and on re exploration showed arachnoiditis without extradural compression.

Roentgenograms —Roentgenograms in this group of patients were not particularly helpful. Narrowed interspaces corresponding to the level of nucleus protrusion were present in only two cases.

arachnoid with localized gross matting together by adhesions of the filaments of the cauda equina. The process usually extended one to two segments above the protruded nucleus pulposus, and was frequently sufficiently marked to cause complete pantopaque obstruction well above the extradural compression. In two instances of complete obstruction, in fact, no extradural protrusion was encountered. Operation was usually undertaken four to ten weeks after onset of acute symptoms and the adhesions were quite firm at this time. There was some increase in vascularity but edema of the roots was not prominent. In two instances, however, the filum terminale was considerably enlarged.

Pathologic sections were available on three of the thirteen patients explored, and an illustrative example of a greatly thickened arachnoid obtained from one patient (M D), compared to a normal and a hyperplastic arachnoid membrane, is included in Fig 3. These sections indicate the type of inflammatory reaction seen in aseptic arachnoiditis. There is little if any leucocytic response even in the active stage, but simply a cellular proliferation of the arachnoid. The end result is a greatly thickened, collagenous membrane associated with adhesions of similar structure.

Course—Follow-up was under one year in three cases, under three years in four cases, and over three years in five cases. In one case, no follow-up was available. One patient was essentially unimproved, four were pain free but one had marked neurologic residua, three were improved but still had pain, and four were improved but reported intermittent episodes of back and leg pain. Postoperative radiation therapy was given to three patients with equivocal improvement.

Postoperatively, improvement was usually slow but progressive. Two patients only had subsequent acute episodes suggesting reactivation of localized subarachnoid aseptic inflammation.

CASE REPORTS

CASE 1 (S.M.H. No. 192019)—C. C. was a 34 year old man who fell approximately one year before admission and immediately complained of pain in the back. Subsequently the pain involved the right leg and later the right arm. These symptoms were continuously increasing to the time of hospital admission.

On examination there was paraspinal muscle spasm, limitation of forward and lateral flexion, a limping gait, reported patchy hypesthesia of the entire right side of the body starting in the region of the eighth cervical segment, and a questionably decreased right ankle jerk.

Roentgenograms of the spine were not particularly remarkable. A pantopaque myelogram revealed a definite defect opposite the fourth lumbar interspace (Fig 1).

At operation a herniated nucleus pulposus was not encountered. On opening the dura the cauda equina in this localized area was found to be involved in a tangle of adhesions in the midst of which was a markedly enlarged filum terminale.

Postoperatively, he was considerably improved and complained of no pain at the time of discharge from the hospital. He did not return for follow up.

Comment—This case illustrates chronic onset of symptoms, spread of complaints, and patchy inconstant equivocal physical findings in the presence of advanced adhesive changes in the cauda equina. Protruded intervertebral disc was not encountered.

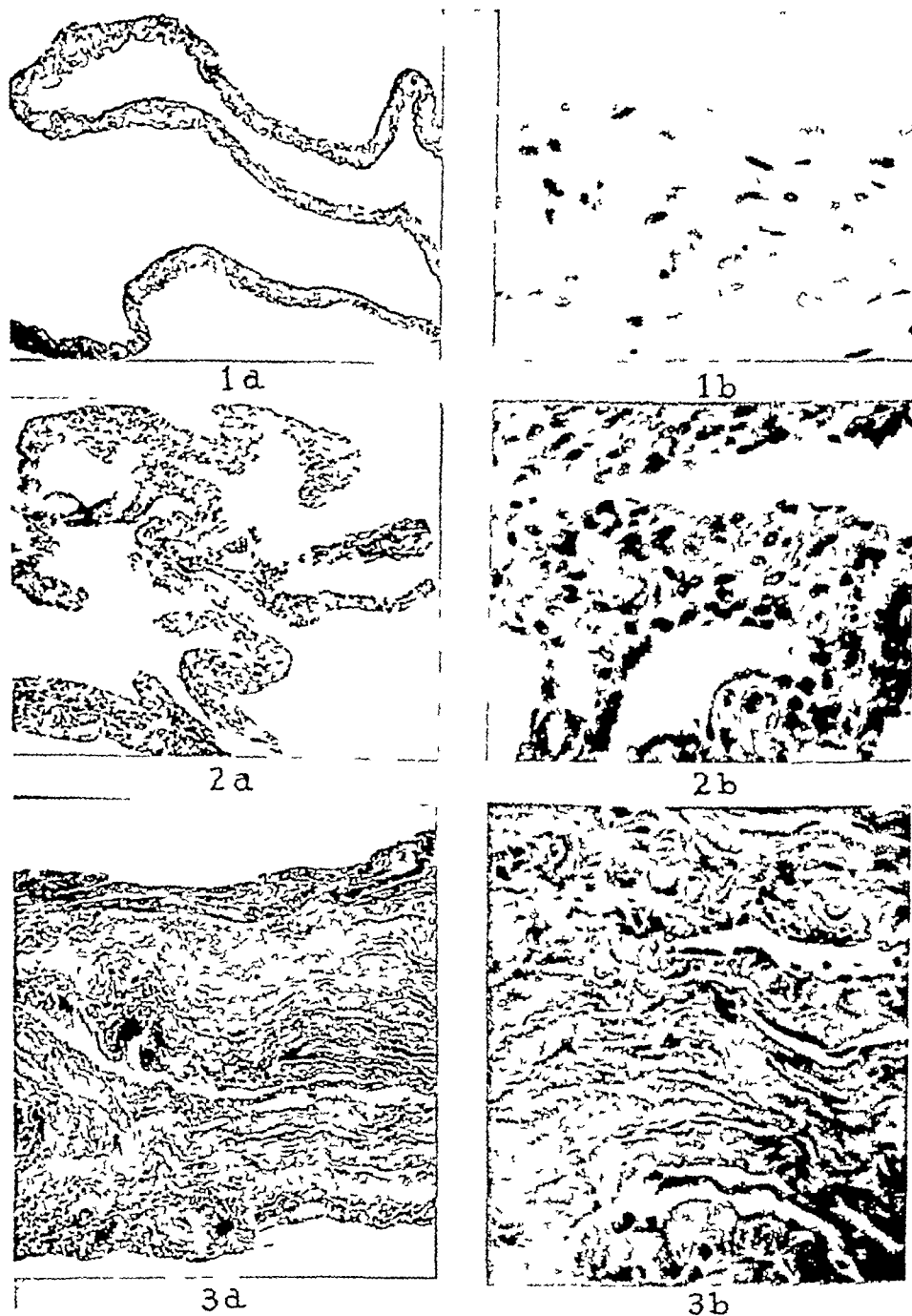


Fig 3—Photomicrographs (hematoxylin and eosin) of normal and inflamed arachnoid membranes under low (a) and high (b) power. Normal arachnoid is shown in 1. Hyperplastic arachnoid changes without leucocytic or vascular reaction is seen in 2 (patient with arachnoiditis associated with spinal cord tumor). The tremendously thickened collagenous membrane (3) represents the end stage of the process (Case 4).

CASE 2 (S M H No 192859) — S S, a 32 year old man, first noticed backache one and one half years before admission while hospitalized because of erysipelas of the face. It lasted three months and then disappeared until seven months before admission, when back pain re-occurred accompanied by pain in both legs. During this seven month period he had undergone an unrevealing exploratory laminectomy and two spinal fusions elsewhere, without relief.

On admission, he was found to have limitation of forward flexion with paraspinal muscle spasm, positive sciatic stretch tests, absent left ankle jerk and diminished right knee jerk, and hyperesthesia of the right outer calf.

A cisternal myelogram demonstrated distortion at the fourth lumbar segment and a block at the fifth. The cisternal fluid protein was 20 mg per cent.

On exploration, a protruded intervertebral disc was removed from the fifth interspace on the left, and gross cauda equina adhesions and matting to above the fourth lumbar segment were encountered on opening the dura.

The postoperative course was uneventful and the patient reported himself well three years later.

Comment — This case illustrates chronic back and leg disability, unrelieved by three operations, which responded well to removal of a protruded intervertebral disc. Localized subarachnoid inflammation was marked and had produced moderate but definite neurologic changes. The symptoms relieved by the final operation were essentially those present from the onset of disability.

CASE 3 (S M H No 199505) — F S was a 29 year old housewife who developed back pain following a normal pregnancy eighteen months prior to admission to the hospital. She responded well to conservative therapy until three days before admission when she suddenly developed severe pain in the back and both legs, numbness in the saddle area and both legs, marked weakness of the feet, and urinary retention.

On examination, she was found to have marked tenderness over the fifth lumbar spine, sensory changes in the saddle area, both feet and lateral thighs, marked weakness in both feet, a distended bladder, absent ankle jerks bilaterally.

Roentgenograms of the lumbar spine showed narrowing of the third, fourth, and fifth intervertebral spaces. Pantopaque myelogram showed a complete block at the third lumbar segment. Spinal fluid protein was 80 mg per cent.

At operation, an extruded nucleus pulposus was removed from the fourth lumbar interspace. Because the block persisted, the dura was opened and the cauda equina seen to be grossly matted together in an adhesive mass.

Postoperatively, the pain disappeared, but three years later she still had some anesthesia and residual foot drop on the left side.

Comment — The case illustrates the acute onset of symptoms and rapid progression of neurologic changes to the point of advanced cauda equina compression. The spinal fluid protein was elevated even though the puncture was done above the site of obstruction. The myelographic block was a full segment above the extruded nucleus pulposus because of the extensive adhesive process visualized at operation. Convalescence was satisfactory although neurologic residua persisted three years after operation.

CASE 4 (S.M.H. No 192500) — M D was a 62 year old Italian man who first noticed twitching in the arms and legs two months before admission. Three weeks before admission he noticed rather severe back pain and pain in the left leg associated with weakness in both legs. At this time he also noted some numbness in the legs below the knees.

On physical examination, he showed evidence of marked weight loss, hypesthesia to pin prick corresponding to levels of about the first lumbar segment on the right side and the third lumbar on the left was present. There was marked weakness of both legs and moderate weak

ness in the arms, fibrillary twitchings in the arms and legs, a diminished left knee jerk, and absent right knee jerk and both ankle jerks. The rectal sphincter was notably relaxed.

Sugar was present in the urine and a fasting blood sugar was 200 mg per cent. Lumbar puncture showed evidence of a complete block and the protein content was 630 mg per cent. Cisternal spinal fluid, however, showed a protein of 25 mg per cent and a lipiodol myelogram three weeks after the onset of symptoms demonstrated a complete block in the region of the second lumbar segment. A laminectomy was performed three days later and an extruded nucleus pulposus encountered between the third and fourth lumbar segments on the right side. The dura was opened and a catheter passed cephalad at which time an obstruction was encountered one interspace above. Exposure was extended and the cauda equina was found to be completely matted together by an inflammatory process involving these segments. After partial separation of the nerves it was possible to pass a catheter freely.

Convalescence was slow but steady. The patient was last seen three years after operation at which time he was completely asymptomatic and working at hard labor.

Comment—This case illustrates advanced patchy neurologic changes out of proportion to the local extradural irritative process. The fibrillary twitching and upper extremity complaints have been observed in other patients. The high spinal fluid protein in this case occurred in fluid which had been removed from below a complete block. Again the visualized block was well above the extradural compression. Recovery was complete.

CASE 5 (S.M.H. No. 153116)—E.R. was a 44 year old woman with a twelve year history of chronic backache. Four months before admission she developed pain in the right leg. On admission to the hospital she was found to have limitation of movements of the back, positive right sciatic stress tests, weakness of the right leg, and a diminished right ankle jerk. A protruded intervertebral disc was removed at the fourth lumbar space after visualization of a simple but definite defect in that area by myelography (Fig. 2).

She was relieved of pain postoperatively until the fourteenth day when she again complained of pain in the back and right leg. Pain and numbness subsequently became bilateral, and on examination sensory changes, weakness, and impaired ankle jerks were present bilaterally. There was some associated bladder disturbance. Myelogram was repeated three weeks later at which time a complete block was apparent at the fourth lumbar segment. At operation, extradural scarring was present, but there was no evidence of nerve root compression. The dura was opened and a localized mass of dense adhesions encountered.

The postoperative course was one of very slow but gradual improvement. X-ray therapy was given but the results were not notable. Two and one half years later the patient had persistent pain in both legs but was active and able to take care of her household duties.

Comment—This case demonstrates sudden onset and rapid progression of manifestations of spinal arachnoiditis two weeks after operative removal of a protruded nucleus pulposus. The patient considered herself improved by operation, but had persistent complaints two and one-half years later.

DISCUSSION

The propensity of the leptomeninges to respond to irritation has been shown both experimentally and clinically many times. Experimentally,¹ relatively minor traumas have been shown to produce such irritation, and arachnoiditis has been induced by application of laked blood, autologous and heterologous sera, homologous tissue, cellophane, various chemicals, and even Ringer's solution. Furthermore, local injury to the arachnoid without injury to the dura has been shown to produce fairly widespread inflammation to both dura and

leptomeninges.² Clinically, leptomeningeal inflammation has been observed following a wide variety of injuries from chemical, particulate, foreign body, traumatic, degenerative, infectious, and other stimuli. The varying character of the inflammation produced and the reported causes have been outlined elsewhere and will not be included here.³

Most of the clinical discussions on spinal arachnoiditis have been concerned with what must represent the more extensive or advanced form of the disease.⁴⁻⁷ Allusion has been made, however, to milder forms of irritation particularly in relation to intervertebral disc disease⁸ and spine abnormalities.⁹ It is probable that minor arachnoidal irritation occurs very frequently, usually as a secondary irritative process, and becomes recognized only when it progresses to such proportions that crippling neurologic changes present themselves.

It seems clear that localized inflammatory changes can frequently result in the spinal meninges as they can in other serous cavities from acute or chronic irritative processes. The predominance with which spinal abnormalities occur in the lumbar region in the form of intervertebral disc disease, instability from many causes, trauma, etc. would, therefore, predispose this area to localized arachnoiditis.

The clinical manifestations presented by these patients with localized lumbar inflammatory processes were essentially similar, yet there were notable differences in extent and intensity of symptoms and in clinical course. Rather meager clinical findings were noted in one group, yet at operation well-developed arachnoid adhesions were found. Paradoxically, others with arachnoiditis in the same area showed acute, rapidly progressive, crippling neurologic changes. It seems probable that arachnoid irritative changes may gradually or intermittently develop or may be much more fulminating, depending upon the local stimulus. The inflammatory process may completely subside coincident with the removal of the irritative lesion, may result in the formation of immobilizing adhesions, or may recur. The resultant clinical manifestations would vary, therefore, according to the degree of subarachnoid irritation and to the structural predisposing changes.

From an evaluation of these patients, it would appear that preoperation determination of arachnoiditis associated with intervertebral disc disease would be difficult but possible. Certain elements in the history and examination may, however, suggest the possibility of its presence.

- 1 The spread of symptoms and findings out of proportion to those produced by compression of a single localized root appear to be most suggestive. Bilateral changes were frequently present in these patients and patchy sensory abnormalities corresponding to higher levels than the suspected area of compression were encountered.

- 2 The acute onset of symptomatology referable to the lower lumbar spine, particularly in people with chronic or recurrent back complaints is commonly seen in association with protruded intervertebral disc. The frequency with which such dramatic onset occurred in the patients reported in this study, particularly when associated with diffusion or rapid progression of symptoms and

findings, suggests that intradural irritative processes may well be present and may possibly even help to explain the intermittent or acute manifestations of known persistent disc protrusions

3 An elevated spinal fluid protein with or without block should also suggest intradural complications. Since spinal fluid protein elevation is encountered in over one-half the patients with protruded intervertebral disc,¹⁰ it is difficult to draw valid conclusions regarding such elevation. There is evidence from two patients reported here, and from five others not included, that spinal fluid protein and even manometric block may undergo rapid changes even in a few days. One patient with arachnoiditis of the dorsal spine showed a protein drop of from 400 mg per cent to 15 mg per cent in eleven days, and a subsequent rise to 600 mg per cent thirty days later. It seems likely, therefore, that the spinal fluid protein is elevated at some stage in spinal arachnoiditis. In considering increased protein content of spinal fluid as an exudative rather than obstructive phenomenon the possibility of arachnoiditis may be entertained under these circumstances.

4 The myelogram may be helpful in directing attention to complicating leptomeningeal involvement. Block was present in over one-half of these patients, and, in still other cases, there was a ragged appearance of the visualized column in addition to a defect on the film.

The treatment of patients with spinal arachnoiditis complicating intervertebral disc disease should be directed primarily at the structural abnormality initiating the irritative arachnoid lesion. Three of seven patients on whom protruded intervertebral discs were removed continued to have significant pain, while three of five patients on whom disc protrusions were not encountered had persistent notable discomfort. A direct surgical attack at the arachnoiditis was not frequently undertaken. Such interference portends more direct damage to the cauda equina than improvement from release of vascularized adhesions. The results of roentgen therapy have not been impressive at this clinic.

It seems likely that the propensity to form adhesions in the subarachnoid space varies considerably in different people in much the same manner as is known to be the case in the large serous or synovial cavities. When such adhesions occur as the result of irritation from a protruded intervertebral disc, the typical anamnesis for such protrusion is altered and the possibility of persistence of symptoms after surgical correction increased. There is evidence, mainly from myelographic and manometric studies on these and other patients, to suggest that regression of the localized adhesive or inflammatory process may occur. Persistent adhesions, however, undoubtedly can perpetuate pain and may be an important factor in that group of patients whose symptoms persist after removal of a nucleus pulposus.

SUMMARY

1 An analysis of thirteen varied cases of localized spinal arachnoiditis in the lumbar region is presented, of which eight were associated with protruded intervertebral disc. In remaining five cases, no disc protrusion was encountered.

2 Factors of possible significance in the diagnosis of localized arachnoiditis are felt to be sudden onset of symptoms, patchy, diffuse physical findings out of proportion to single root compression, increased spinal fluid protein, and myelographic abnormalities

3 The operative findings consisted chiefly of thickened arachnoid and localized agglutination of the cauda equina filaments by dense adhesions

4 It is suggested that spinal arachnoiditis may be a common complication of intervertebral disc disease

REFERENCES

1. Harvey, S C Meningeal Adhesions and Their Significance, Inter State Post Grad M A North America Proc 2 27, 1926
2. Lear, M, and Harvey, S C The Regeneration of the Meninges, Ann Surg 80 536, 1924
3. Ramsey, G H, French, J D, and Strain, W H Intervertebral Disk and Spinal Cord, Clinical Radiology, G Pillmore, Ed, Philadelphia, 1946, F A Davis Company Vol II, p 132
4. Vincent, C, Puech, P, and David, M Sur le diagnostic, le traitement chirurgical, le pronostic des arachnoiditis spinales, Rev Neurol 1 577, 1930
5. Mauss, T, and Kruger, H Ueber die unter dem Bilde der Meningitis Serosa Circumscripta verlaufenden Kriegschadigungen des Rueckenmarks und ihre operative Behandlung, Duetsche Ztschr f Nervenhe 62 1, 1918
6. Elkington, J St C Meningitis Serosa Circumscripta Spinalis (Spinal Arachnoiditis), Brain 59 181, 1936
7. Stookey, B Adhesive Spinal Arachnoiditis Simulating Spinal Cord Tumor, Arch Neurol & Psychiat 17 151, 1927
8. Barr, J S, and Mixer, W J Posterior Protrusion of the Lumbar Intervertebral Discs, J Bone & Joint Surg 23 444, 1941
9. Landgren, E Myelographic Changes in Kyphosis Dorsalis Juvenilis, Acta. radiol. 22 470, 1941
10. Poppen, J L The Herniated Intervertebral Disc An Analysis of 400 Verified Cases, New England J Med 232 211, 1945

PERFORATION OF A DUODENAL ULCER DURING ROENTGEN EXAMINATION

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PERFORATION of a peptic ulcer during or shortly following barium contrast meals is a dramatic though uncommon occurrence. Because of their spectacular and startling nature, most cases that occur are reported. Seldom, however, are there follow-up studies on these cases with regard to the most interesting aspect, namely, the immediate course and the later disposal of the contrast substance in the peritoneal cavity. Considerable research has been conducted in animals regarding the peritoneal response to foreign materials. Also, animal and post-mortem experiments have been performed in an attempt to trace the various routes and method of spreading infection and peritoneal effusions. It is, therefore, a rare opportunity to observe the immediate and later course of barium sulfate in the peritoneal cavity of a man for several months following its accidental introduction through a spontaneous duodenal perforation. This occurred in fluoroscopy during the course of a routine gastrointestinal roentgen examination.

In the cases reported in the literature most peptic ulcers that have perforated in relation to barium contrast meals have perforated a few hours or days following the ingestion of the contrast substance. In such cases little or no barium contaminated the peritoneal cavity. Very few cases were actually observed in fluoroscopy at the time of examination. Himmelmann,⁸ Paas,¹⁴ and Buttner and Fangerau¹ found a significant relationship between perforation of peptic ulcers and roentgen examination. Panek¹⁵ reported that 22 per cent and Himmelmann⁷ reported that 29.4 per cent of the perforated gastric and duodenal ulcers seen by them followed a barium meal and roentgen examination. Singer,¹⁸ at the Cook County Hospital in Chicago, found no such incidence. Out of 500 perforated ulcers only four occurred after a barium meal, an incidence of 0.8 per cent. During this period 5,000 roentgenologic examinations were carried out in patients with peptic ulcers. Therefore, the incidence of perforation following examination of all unruptured peptic ulcers was 0.08 per cent. Eckman⁵ at Duluth reported five cases of perforation following barium ingestion in a series of 500 cases of perforated peptic ulcers. At that clinic 1,500 gastrointestinal roentgen examinations were averaged per year for all reasons. The case reported here is the first in the history of this hospital, now almost twenty years old. Here also, an average of 1,500 gastrointestinal roentgen examinations for all reasons are carried out yearly. Recently, the total number of such examinations approached 2,500 per year. During the same period there have been nearly 200 perforated peptic ulcers. None of these were related to barium

ingestion and roentgen examination. Thus, despite foreign statements to the contrary, the perforation of an ulcer during or immediately following gastrointestinal roentgen examination is a rare event. Heavy palpation during fluoroscopy, as described and stressed in German reports, may account for this discrepancy in incidence.

At present, fifty-seven cases have been found in the literature. Singer collected thirty-four cases and added four of his own. Buttner and Fangerau reported fifteen cases in the literature not mentioned by Singer and added one of his own. Paas added two cases to his review of this literature. Thomas²⁰ reported a single case. Johanson⁹ and Toropov²¹ listed cases, although unfortunately in journals unobtainable.

The subject of barium in the peritoneal cavity has been studied by three observers. Himmelmann,⁷ using twenty-one healthy dogs, perforated their stomachs with cautery after instilling varying amounts of barium and sterile and unsterile food. At a second laparotomy the perforations were closed. He concluded that perforations following a contrast meal of barium were more dangerous than after the usual nutritive feedings in dogs. Accordingly, a similar situation in man was judged to be more serious. He noted roentgenographically an early widespread diffusion of barium. Microscopically, he observed an encapsulating foreign body type of reaction in the peritoneal cavity.

Paas in more extensive experiments found that pylorospasm occurred after perforation of the duodenum in dogs. There was a marked delay in contamination of the peritoneal cavity with barium contained in the stomach under such circumstances. This delay lasted often more than five hours compared with the rapid contamination occurring after perforation of the stomach. There was a much higher mortality after perforation of the stomach than after perforation of the duodenum. Barium injected into the peritoneal cavity was found to diffuse rapidly and to cause death within twenty-four hours if more than 50 cc of barium suspensions were used. His microscopic findings were similar to those of Himmelmann.

Thomas²⁰ made a very careful study of the peritoneal reaction to barium sulfate by injecting 0.2 to 0.4 cc of barium sulfate suspension into the peritoneal cavities of albino rats. He concluded that there was a transient, nonspecific polymorphonuclear leucocyte migration, a marked lymphocytic and macrophagic response, and later encapsulation with granulation tissue. Most of the barium sulfate particles were phagocytosed by macrophages. Foreign body giant cells formed only late and in small numbers. He stated that the peritoneal response differed from the classical foreign body reaction in that there was an intense and persistent lymphocytic and polyblastic reaction with delayed and slight formation of giant cells. No statements were made regarding the intraperitoneal lymph nodes.

Attention should be called to the recent paper of Simer¹⁷ regarding the drainage of India ink and indigo carmine from the peritoneal cavity of cats. He noted free ink in the lymphatics of the diaphragm and in the parasternal

lymph trunks and sternal lymph nodes within a few minutes of injection. A large amount of the material remaining in the peritoneal cavity adhered to the greater omentum and was rapidly immobilized by a fibinous deposit. Later almost all particles were picked up by macrophages and carried deeper into the interstitial connective tissue of the omentum.

The subject of peritoneal reactions, the intraperitoneal absorption of various foreign substances, cellular response to foreign materials, and the ultimate disposal of particulate matter, has been extensively studied. The reviews and the experimental studies of Webb,²² Mackmull and Michels,¹¹ Bolton,² Cunningham,^{3, 4} Hahn and associates,⁹ and Miller and associates¹² may be referred to for complete discussion of specific aspects of these questions. In general, peritoneal absorption of fluids and foreign substances is accomplished through the diaphragm, omentum, mesentery, and the peritoneal surfaces with extraordinary rapidity. The type of material and the size of the particles influence the rate and degree of absorption as well as the type of cellular response. Neutrophils, macrophages, and mesothelial cells are essential in the removal of particulate matter. The absorbed material is widely distributed in the omentum, liver, spleen, lungs, and distant organs of various animals through the subserous capillaries and lymphatics. These remarkable peritoneal responses are not restricted to finely divided particulate matter. The encapsulation of almost every conceivable type of foreign body including drains has been the subject of innumerable papers. The case to be presented is further evidence of the remarkable protective ability of the peritoneal cavity of man. Moreover, in this single case, there is corroboration of important experimental conclusions to be discussed later.

CASE REPORT

W. B. (No. 235220) was admitted to the Rochester Municipal Hospital for the first time July 17, 1945. He was a 72 year old white man, single, kitchen helper, with the chief complaints of anorexia, diarrhea, and abdominal pain of one month duration.

The patient had been in good health until one month before admission when he noted a stabbing, burning, epigastric pain, that was most severe around midnight. The pain was not related to meals, but was partially relieved by food. At the same time he noted pain about the heart, that radiated down the left arm, which was more marked on exertion. During this period he suffered alternate bouts of constipation and diarrhea with complete loss of appetite, and a weight loss of ten to fifteen pounds. One week before admission the patient vomited frequently, although the vomitus contained no black or coffee ground material. The night before admission the patient passed two large black tarry stools. He had a similar bout one year before admission that subsided spontaneously.

The past history revealed no serious illnesses, operations, injuries, or other hospital admissions and was noncontributory.

Physical examination at the time of admission revealed a well developed, thin man in no acute distress although appearing chronically ill. The temperature was 36.7° C., the pulse 76, and the respirations 18 per minute. The blood pressure was 164/82. The skin was dry with loss of elasticity. A cataract was noted in the left eye. Teeth were carious. The heart and lungs were within normal limits. There were palpable, shotty cervical and axillary lymph nodes. Abdominal examination revealed epigastric tenderness without spasm on deep palpation. The liver was palpated at the costal margin.

Laboratory studies at the time of admission were within normal limits except a plasma protein of 5.5 Gm. per cent.

Two days after admission, a gastrointestinal roentgen examination was carried out with barium sulfate ingested as the contrast substance. A 250 cc suspension was swallowed, containing 200 Gm of barium sulfate. During fluoroscopy, barium was observed to streak out to the right and the left of the duodenal cap and very promptly outlined the right lower boundary of the peritoneal cavity. An x-ray film taken one and one half hours later showed barium spread widely throughout the peritoneal cavity though concentrated in the right and left lateral gutters. The blood amylase determined at this time was 80 units and white blood cell count was 5,000 per cmm.

The patient was removed to the operating room shortly after the last roentgenogram was taken. The abdomen was entered through an upper right rectus incision. At the time of operation the patient received 500 cc of citrated blood and 250 cc of plasma. A large perforation, 1.5 cm in diameter, was found on the anterior portion of the first part of the duodenum just distal to the pylorus. A great deal of black watery fluid was noted. Everywhere there were flecks and small collections of whitish material which in the course of three hours were mixed and agglutinated by a fibrinous exudate. It was impossible to remove any barium without damaging the serosa of the intestines. Accordingly, as much of the free fluid was aspirated as possible and the perforation was closed transversely to the long axis of the duodenum with a double row of interrupted silk sutures. Omentum was sutured over the perforated area. The abdominal wound was closed tightly in layers with interrupted silk sutures. No drains or sulfonamides were placed in the peritoneal cavity.

The postoperative course although somewhat stormy was much more uneventful than expected. The patient received intravenous glucose, saline solution, and amigen. Wengsten suction was applied to an indwelling Levine tube. Sulfadiazine was administered intravenously, but discontinued after thirty six hours because of a rising nonprotein nitrogen. Penicillin, 20,000 units, was given intramuscularly every three hours. The nonprotein nitrogen rose to 92 mg per cent four days after operation and thereafter dropped slowly. A small pleural effusion developed in the right side of the chest one week after operation and slowly subsided without aspiration. At this time the plasma protein was 4.93 Gm per cent, and shifting dullness was noted in the abdomen. Some peripheral edema of the lower extremities was also present. During the entire postoperative period after the first day, the patient was placed in a chair twice daily. Two weeks postoperatively the oral intake approximated 3,000 calories a day. Coincident with the ability to tolerate and retain food, the patient began to improve clinically, and the total proteins rose to 5.6 Gm per cent. During the first three weeks postoperatively the patient suffered from crampy abdominal pain and diarrhea. A large tender pelvic mass was palpable by rectum and slowly subsided. Four weeks postoperatively a mild superficial phlebitis of the lower extremities was noted and treated expectantly with spontaneous remission. During the next month the patient was essentially asymptomatic. He was not discharged because of lack of convalescent facilities. During this period there was a persistent leucocytosis of 10,000 to 20,000 white cells per cmm with an eosinophilia averaging 23.5 per cent. This subsided slowly after discharge.

The patient was discharged twelve weeks after admission. Two months later he appeared remarkably well. Appetite was good, there was no difficulty in bowel movements. There was no crampy abdominal pain or obstructive symptoms. The patient had gained two kilograms of weight. There was still some residual induration high in the pelvis on rectal examination. Four months later he appeared the same. All the induration in the pelvis palpable by rectum had disappeared. White blood cell count was normal, plasma total proteins were 6.9 Gm per cent.

DISCUSSION

An important aspect of this case study is the corroboration of Mitchell's¹³ research on the spread of intraperitoneal effusions. He injected finely suspended barium into the lesser omental sacs of human stillborn infants. He concluded that an effusion in the right subhepatic space overflows into the right

infracolic space between the liver, gall bladder, transverse colon, and falciform ligament. The effusion then involves the right lumbar gutter or paracolic groove by a spread across the ascending colon and cecum. The right subphrenic space is then involved, and not directly from the subhepatic space as is commonly thought. The left subphrenic space is involved by direct spread from the left infracolic spaces and paracolic groove. The left subphrenic space is also involved to a lesser extent from the right and left subhepatic spaces.

The first x-ray film (Fig. 1) shows very clearly the cascading of barium from the duodenal cap into the subhepatic space and downward to the right infracolic region. There is concentration of barium low in the right lumbar gutter. The subphrenic spaces are not involved in the effusion. The left lumbar gutter and superior boundary of the pelvis are clearly outlined. This view was taken one and one-half hours after the perforation occurred. Barium may be seen crossing the ascending colon in one area into the right paracolic region. It is interesting and important to note that the wide diffusion depicted here was observed almost immediately after perforation in fluoroscopy.

Steinberg and Martin¹⁰ studied the diffusion and localization of intraperitoneal infections by instilling radiopaque iodized oil in the pelves and appendices of dogs. A ligature was tied tightly around the base of the appendix and its mesentery. The subsequent rupture of the appendix and diffusion of the instilled material was observed and recorded roentgenographically. They noted a very rapid and uniform diffusion of the material throughout the peritoneal cavity. This has been noted by most observers who have instilled finely divided particulate matter into the peritoneum. There were greater densities of this material at the site of perforation, under the right diaphragm, and in the lateral gutters. A period of thirty-six hours was necessary for sufficient mobilization of the intraperitoneal defense mechanisms to prevent this diffusion. Their work very nicely demonstrates the extremely important fact that peritoneal infections primarily diffuse widely and rapidly and are then localized secondarily by the peritoneal defenses. Their conclusions are supported by the observations in the case presented with respect to the rapidity and relative diffuseness of the spread of a heavy radiopaque substance, barium. As stressed by Steinberg and Martin, this diffusion is not inimical but an essential in the peritoneal defense mechanisms.

After the first few days there was very little movement of the barium in the peritoneal cavity of the patient presented here. This coincides with the operative findings that the particles of barium were clumped and agglutinated to surrounding structures by fibrin three hours after perforation. The lateral gutters, pelvis, and particularly the right subphrenic region, were more densely outlined in the course of a few weeks (Figs. 2, 3, and 4). Thomas noted that the intestines were relatively cleared of barium particles within twenty-four hours in rats. There was a concomitant concentration of barium in the lateral gutters. This he attributed to the mechanical effects of peristalsis that he observed directly. A similar mechanism may have occurred in the patient re-

ported on with regard to the later movement of the barium-filled macrophages. During the last two months there has been essentially no change in the films of the abdominal cavity.

To obtain gross material for personal microscopic study 50 cc of an unsterile barium sulfate suspension were injected into the peritoneal cavity of three large healthy dogs, averaging 60 pounds in weight. The post-mortem findings in these dogs were interesting enough to warrant recording here.

The barium suspension, containing 40 Gm of barium sulfate, was injected through a 16 gauge needle into the right superior quadrant under nembutal anesthesia. The dogs were quite ill for one week and one appeared near death.



Fig 1—Flat abdominal x-ray film taken at time of perforation. Note barium concentrations in the right and left lower quadrants. No barium is present deep in the pelvis or in the right subphrenic space.

for thirty-six hours. The dogs refused food, drank little water, retched, and vomited frequently. There was a period of anorexia after which the dogs appeared and acted completely normal. X-ray pictures were taken of the abdomens of the dogs one, two, and three hours following injection, during which



Fig. 2—Flat abdominal x-ray film taken ten days after perforation. Note the definite outlining of the liver and right subphrenic area. Barium is more concentrated in the pelvis.

time a wide diffusion of barium was noted (Fig. 5). Barium was most dense at the site of the injection and remained there during the life of the animals. The dogs were sacrificed at intervals of $1\frac{1}{2}$, 3, and $4\frac{1}{2}$ months. In subsequent x-ray examinations of the peritoneal cavity before sacrifice, the barium particles remained stationary.

Post-mortem studies revealed barium sulfate most concentrated at the site of injection encapsulated by dense fibrous and omental adhesions. Small deposits of barium were observed throughout all portions of the peritoneal cavity the pelvis and the undersurfaces of the diaphragm. Particles were



Fig. 2.—Flat abdominal x-ray film taken thirty-eight days after perforation. There is essentially no change from previous films except greater densities of barium in the pelvis and right subphrenic areas.

adherent to the bowel loops, liver, kidneys, spleen, and urinary bladder. Wherever small deposits or particles were present there were also dense adhesions, particularly between bowel loops and to the parietal peritoneum. These required sharp dissection for separation. The mesenteric lymph nodes were enlarged

and several were white with a pasty, amorphous substance on cross section. The lymph nodes near the internal mammary vessels at the second interspace in the thorax contained barium. A roentgenogram of the thorax of one dog just before death demonstrates the migration of phagocytosed barium to the lymph nodes in the thorax (Fig. 6). The third dog sacrificed showed a remarkable



Fig. 4—Flat abdominal x-ray film taken 139 days after perforation. There is essentially no change from previous films except migration of presumably phagocytized barium centrally in small amounts.

picture with the lymphatics of the omentum and mesentery beautifully outlined by barium (Fig. 8). The microscopic picture was one of fibrous encapsulation of small clumps and particles of barium, round-cell infiltration, and a marked phagocytic cell response with ingestion of barium particles. Foreign body

giant cells were noted in certain areas in moderate numbers. The lymph nodes showed considerable hyperplasia of their lymphoid and reticuloendothelial tissue. In some the entire structure of the lymph node was destroyed by a stuffing of the sinusoids with macrophages filled with refractile barium particles (Fig 7). Microscopic study of the omentum, shown in Fig 8, revealed all barium particles



Fig 5—Flat abdominal x-ray film of abdomen of a dog immediately after injection of 50 c.c. of a barium sulfate suspension into the peritoneal cavity. Note the rapid and wide diffusion.

contained in large single and often multiple confluent macrophages. Except for an occasional lymphocyte, there was no accompanying inflammatory reaction or fibrosis. The omentum was also free of any adhesions in the areas shown, though densely adherent in other areas where it mechanically encapsulated

small and large clumps of barium. Except for the numerous dense adhesions to and between the various abdominal organs, no other abnormalities were noted.

In repeated x-ray films of the chest of the patient reported, there is no evidence of infiltration of cervical or mediastinal lymph nodes with barium. Although there have been no symptoms suggestive of intestinal obstruction, it may be assumed that numerous intraperitoneal adhesions exist. The patient now shows no ill effects whatsoever from the experience and has no further ulcer symptoms.



Fig. 6—Substernal intrathoracic lymph node filled with phagocytized barium sulfate four and one-half months after intraperitoneal injection of 50 c.c. of a barium sulfate suspension in a dog.

One clinical finding that deserves special mention is the marked eosinophilia that occurred eight weeks postoperatively and which lasted for a period of approximately two months. At times this eosinophilia would reach 30 per cent of the differential count with a total white blood cell count of around 20,000 per c.mm. At present, six months later, the white blood cell count is normal.

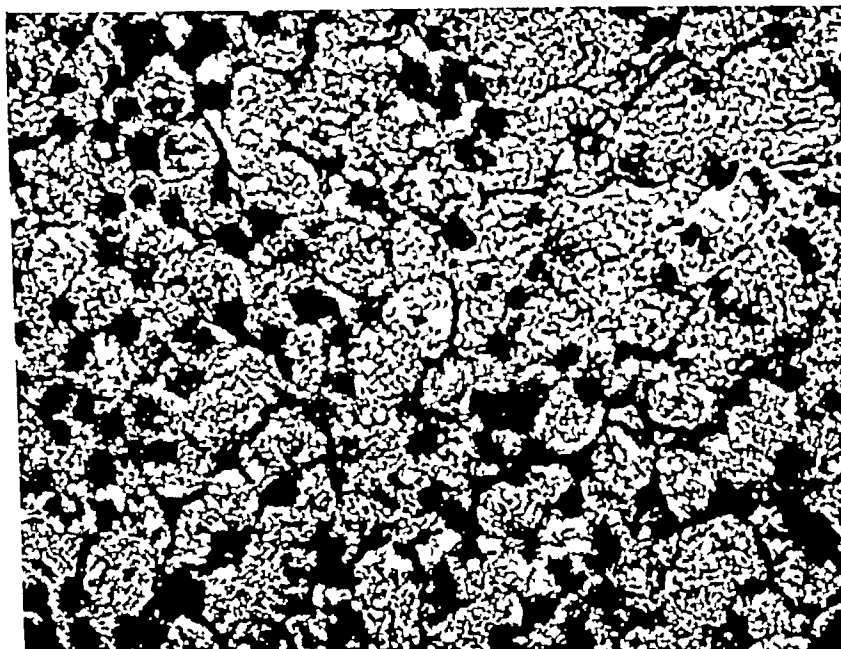


Fig 7—Microscopic picture of intrathoracic lymph node of a dog shown in Fig 6 Note the distortion of the normal architecture by barium-filled macrophages

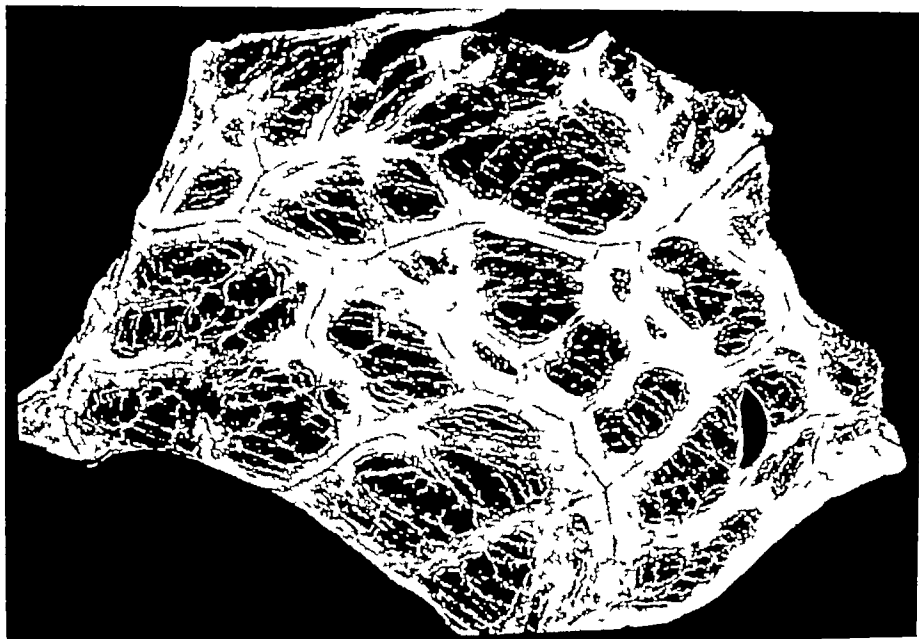


Fig 8—Approximately 64 sq cm of greater omentum of a dog four and one-half months after the intraperitoneal injection of 50 c.c. of a barium sulfate suspension Note the distribution of barium in the lymphatic channels

with a normal differential count and smear. The eosinophiles comprise approximately 4 per cent of the total. No other cellular abnormalities were ever noted in the smear. One paper¹⁶ is found in the literature that stresses eosinophilia in chronic peritonitis. Kirk¹⁰ in a recent exhaustive review of the literature regarding the etiology and significance of eosinophilia does not mention chronic peritonitis. Without confirmatory cases and experimental data it cannot be stated conclusively that the eosinophilia was related here to a chronic, non-specific peritonitis. However, the relation seems more than merely coincidental and suggests possibilities for further study regarding the etiology and significance of eosinophilia.

A fact that should be stressed in the operative management of this case is the nondrainage of the peritoneal cavity despite the knowledge that much foreign material was not removed. It was felt that drainage here would not only be useless, but actually harmful, in agreement with the conclusions of Yates²³ in his monumental work of 1905 regarding the fallacies of draining the peritoneal cavity. These concepts have long been stressed by Dr. Morton as a necessity for decreased surgical morbidity and mortality.

SUMMARY

A case is presented where a large perforation of the duodenum occurred during a routine gastrointestinal roentgen examination in fluoroscopy. Barium sulfate was used as the contrast substance. The effusion of barium into the peritoneal cavity was observed in fluoroscopy and recorded with repeated abdominal x-ray films. The patient has been followed at frequent intervals with repeated x-ray films of the abdomen and thorax. The immediate and later course of barium in the peritoneal cavity is described and discussed with a review of the pertinent literature.

The effusion into the peritoneal cavity from the anterior portion of the first part of the duodenum descended first to the right intracolic region, crossed the ascending colon and cecum into the right lateral lumbar gutter, and then involved the right subphrenic area and space.

There was an immediate and rapid diffusion throughout the peritoneal cavity of the patient with later concentration of the barium in the lateral gutters, pelvis, and the right subphrenic regions.

Barium sulfate was injected into the peritoneal cavity of three dogs. An immediate widespread diffusion of barium was noted roentgenographically. The dogs were sacrificed at 1½ month intervals. Post-mortem examination showed dense fibrous adhesions at the site of widespread barium deposits with omental encapsulation of a great portion of the barium at the site of injection. Barium was noted microscopically and roentgenographically in thoracic lymph nodes. The lymphatics of the greater omentum were outlined by phagocytosed barium. The local microscopic reaction was one of fibrous encapsulation, lymphocytic infiltration, and phagocytosis of barium by macrophages. Foreign body giant cells were few in number.

REFERENCES

- 1 Buttner, G, and Fangerau, W Ueber Geschwursdurchbrücke im Magen—und Darmkanal in Anschluss an Röntgenkontrast mahlzeiten, Beitr z klin Chir 170 58 76, 1939
- 2 Bolton, C Absorption From the Peritoneal Cavity, J Path & Bact 24 429-445, 1921
- 3 Cunningham, R S Studies in Absorption From Serous Cavities, Am J Physiol 62 248 260, 1922
- 4 Cunningham, R S The Physiology of the Serous Membranes, Physiol Rev 6 242 280, 1926
- 5 Eckman, P F Acute Perforation Following Barium Filling in Routine Gastrointestinal Examination, Surg, Gynec & Obst 47 858 860, 1928
- 6 Hahn, P F, Miller, L L, Robscheit Robbins, F S, Bale, W F, and Whipple, G H Peritoneal Absorption, J Exper Med 80 77 82, 1944
- 7 Himmelmann, W Tierexperimentelle Untersuchungen über die Folgen der Magenperforation nach Röntgenkontrastmahlzeit, Deutsche Ztschr f Chir 240 62 87, 1933
- 8 Himmelmann, W Ueber die Perforation im Bereich des Magen Darmtraktes bei und nach der Röntgenbreipassage, München med Wehnschr 79 1567 1570, 1932
- 9 Johanson, C E Perforation of a Gastric Ulcer After Roentgen Examination, Nord med 8 2542 2546, 1940
- 10 Kirk, R C The Causes of Eosinophilia, Internat Clin 1 219 233, 1942
- 11 Mackmull, G, and Michels, N A Absorption of Colloidal Carbon From the Peritoneal Cavity in the Teleost, Tautogolabrus Adspersus, Am J Anat 51 3 49, 1932
- 12 Miller, J W (Washington, D C), Sayers, R R, and Yant, W P Response of Peritoneal Tissue to Dusts Introduced as Foreign Bodies, J A M A 103 907 912, 1934
- 13 Mitchell, G A G The Spread of Acute Intraperitoneal Effusions, Brit J Surg 28 291 313, 1940
- 14 Paas, H E Ueber die Magen und Duodenalperforation nach Röntgen Kontrastmahlzeit und ihre Folgen, Deutsche Ztschr f Chir 247 461 494, 1936
- 15 Panek, O Ueber Ucusperforationen im Anschluss an Röntgen untersuchungen, Med Klin 23 1492 1494, 1927 (Quoted by Singer¹⁸)
- 16 Parsons, C G Eosinophilia With Chronic Peritonitis, Lancet 1 721 723, 1945
- 17 Simer, P H The Drainage of Particulate Matter From the Peritoneal Cavity by Lymphatics, Anat Rec 88 175 192, 1944
- 18 Singer, H A Perforation of Peptic Ulcer Following X ray Examination With a Barium Meal, Radiology 22 181 187, 1934
- 19 Steinberg, B, and Martin, R A Diffusion and Localzation of Experimental Infections of the Peritoneum, Surg, Gynec & Obst 79 457 468, 1944
- 20 Thomas, J C The Disposal of Barium Sulfate in the Abdominal Cavity, J Path & Bact 43 285 298, 1936
- 21 Toropov, N I Case of Perforation of Duodenal Ulcer After Roentgen Examination, Khirurgiya 4 118 120, 1937
- 22 Webb, R L Peritoneal Reactions in the White Rat, With Especial Reference to the Mast Cells, Am J Anat 49 283 334, 1931
- 23 Yates, J L An Experimental Study of the Local Effects of Peritoneal Drainage, Surg, Gynec & Obst 1 473, 1905

MULTIPLE INVASIVE CARCINOMAS OF THE LARGE INTESTINE

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PATIENTS with multiple carcinomas of the large intestine constitute almost 3 per cent of the 726 cases of histologically verified cancer of the colon and rectum that have been recorded at the Strong Memorial and Rochester Municipal Hospitals during the past nineteen years. Four of the twenty-one patients in the group had metachronous lesions, while the carcinomas occurred synchronously in the other seventeen.

Billroth's criteria for the diagnosis of multiple cancers have been modified by Warren and Gates¹. Only those lesions in which there was histologic evidence of invasion of the submucous tissue by the neoplastic cells have been included in this series. Definite invasion of the stalk was required for the diagnosis of carcinoma in pedunculated polypoid masses. This should not be construed to indicate that heterotopia is the *sine qua non* of carcinoma in the large intestine. However, the frequency of cure by local excision of a large pedunculated polyp containing a focus of carcinomatous tissue at its periphery suggests that some unknown factors may make this lesion biologically different from invasive cancer regardless of similarity in structural details.

Data pertinent to the individual cases discussed herein are listed in Table I. There are no apparent significant differences in mean age, sex distribution, or anatomic locations of the intestinal carcinomas between those patients who had multiple cancers and those who had only one carcinoma (Table II).

Roentgenologic examination of the large intestine with the conventional barium enema disclosed definite filling defects corresponding to the carcinomatous lesions found at operation or autopsy in each of the ten patients who was examined by this technique. The barium filled the entire colon in each instance. Had there been complete obstruction of the lumen it surely would have been impossible to outline a lesion proximal to the obstructed point. Some surgeons omit roentgenologic examinations of the large intestine in those patients who have lesions that can be visualized by endoscopy, particularly when biopsy is possible. Similarly, a palpable mass in the abdomen of a patient who gives a characteristic history of a large bowel neoplasm may be considered an adequate indication for exploratory laparotomy. Economic considerations may influence the use of diagnostic procedures in individual cases.

Experience indicates that examination of the colon at operation is an effective means of diagnosis of multiple carcinomas of that organ. The correct diagnosis of multiple cancers was made in six of the seven patients who were operated upon without prior roentgenologic studies with barium techniques. The one patient in whom the neoplasm was not found at operation (Case 10) had diabetes mellitus and hypertensive cardiovascular disease. She died four days

after right hemicolectomy for carcinoma of the cecum. A carcinoma of the transverse colon, 6 cm long and 4 cm wide, which was raised slightly above the surrounding mucosa, was found at autopsy. The lesion could have been excised by including approximately 20 cm more of the transverse colon in the resection. The point is of academic interest in this case but conceivably a second carcinoma might be missed in a more rugged individual. Extensive exploration of the abdominal contents of a debilitated patient in the presence of an obvious lesion which readily explains the symptoms may increase the risk of operation. Only two of the seventeen synchronous carcinomas involved both the right and left portions of the large intestine. This tendency for synchronous multiple carcinomas to involve the same or neighboring segments of the large intestine reduces the hazard of erroneous diagnosis at laparotomy.

Neither roentgenologic examination nor palpation of the colon at operation has been an effective method for detecting small adenomatous polyps of the large intestine. Perhaps double contrast techniques have not been employed frequently enough, but, in general, the results have been discouraging save for those patients in whom large areas of the colonic mucosa were involved. Multiple adenomatous polyps were found in the large intestines of eight (38 per cent) of the patients in this series. The involvement of the intestine was sufficiently diffuse in four of them to constitute polyposis.² A familial history of polyposis could be elicited from one patient (Case 6). The importance of the association of polyps with multiple carcinomas of the large intestine is illustrated well by the patients in whom cancers occurred metachronously. Three of the four had polyps but none had extensive involvement of the large intestine. In Case 1 no polyps were found in a segment of colon 12 cm long but four years later approximately fifteen were clustered about a carcinoma of the rectum. Only two more polyps were found in the entire descending colon in addition to a carcinoma. One patient (Case 2) had ten polyps in the proximal part of the ascending colon which were not seen on roentgenologic examination. At autopsy three years later there were polyps separated from each other by large areas of normal-appearing mucosa in all of the remaining segments of the large intestine. Another patient (Case 3) had two small polyps in the proximal 28 cm of the colon. No polyps were found in the remaining large intestine at autopsy six years later. Case 7 is particularly interesting. This 61-year-old housewife had an abdominoperineal resection for rectal carcinoma in July, 1943. The operative specimen, 30 cm long, contained two typical carcinomas approximately 8 cm apart. The intervening mucosa was studded with thirteen small polyps, 3 to 5 mm in diameter. The distal 35 cm of the remaining colon were resected subsequently, and contained only three small polyps.

The difficulties in diagnosis of adenomatous polyps of the large intestine make it impossible to determine the true incidence of polyps associated with single carcinoma in surgically resected specimens. Among 9,000 autopsy protocols at Strong Memorial and Rochester Municipal Hospitals there are 191 cases of single carcinoma of the large intestine. Thirty-three (17 per cent of these patients) had one or more adenomatous polyps in either the surgically resected specimen or at necropsy, less than one-half the incidence of polyps associated

TABLE I

CASE	AGE	SEX	LOCATION OF TUMOR	PATHOLOGIC DIAGNOSIS	METAS *	POLYPS	RESULT
<i>Metachronous</i>							
1	64 70	M	Splenic flexure Rectum Descending colon	Ulcerating adenocarcinoma Ulcerating adenocarcinoma Ulcerating adenocarcinoma	- - -	None Many in rectum, 2 in descending colon	Apparently well 3 yr
2	60 63	M	Cecum Splenic flexure	Papillary adenocarcinoma Fungating carcinoma	- -	Few Polyps	Died, autopsy
3	68 74	F	Ascending colon Transverse colon	Annular adenocarcinoma Fungating adenocarcinoma	- -	2 in cecum None	Died, autopsy
4	54 55	F	Cecum Transverse colon	Fungating adenocarcinoma Fungating adenocarcinoma	- -	None None	Apparently well 16 yr
<i>Synchronous</i>							
5	51	M	Rectum Sigmoid colon Descending colon	Ulcerating adenocarcinoma Papillary adenocarcinoma Ulcerating adenocarcinoma	+ - +	Polyposis hepatic flexure to anus	Apparently well 1 yr
6	21	F	Sigmoid colon Descending colon	Papillary adenocarcinoma Annular adenocarcinoma	-	F familial polyposis	Died, autopsy
7	40	M	Rectum Sigmoid colon Sigmoid colon	Annular adenocarcinoma Annular adenocarcinoma Annular adenocarcinoma	- - -	Polyposis left half of colon	Apparently well 3 yr
8	61	F	Rectum Rectum	Papillary adenocarcinoma Ulcerating adenocarcinoma	- +	13 in rectum, 3 in descending colon	Died in 14 mo, au topsy
9	65	F	Rectum Rectum	Papillary adenocarcinoma Ulcerating adenocarcinoma	- -	Rectum only	Died in 23 mo
10	48	F	Cecum Transverse colon	Ulcerating mucinous adenocarcino ma Fungating mucinous adenocarcino ma	- -	None	Died, autopsy

TABLE II AGE, SEX, AND ANATOMIC LOCATION OF CARCINOMAS OF THE LARGE INTESTINE

	SINGLE	MULTIPLE
Mean age	60 years	61 years
Males	53%	48%
Females	47%	52%
Cecum to splenic flexure	20%	22%
Splenic flexure to rectum	37%	40%
Rectum	43%	38%

with multiple carcinomas of the large intestine. One or more polyps lay in the same segment as the carcinoma in fourteen (42 per cent of those who had a single cancer and polyps). At least one polyp was found in the carcinomatous segment of the colon in all of the patients who had multiple cancers and polyps. It appears, then, that patients with multiple carcinomas have concomitant polyps of the colon and rectum more frequently than do patients with solitary carcinoma. We are unable to show that multiple carcinomas arise more frequently among patients who have adenomatous polyps of the large intestine.

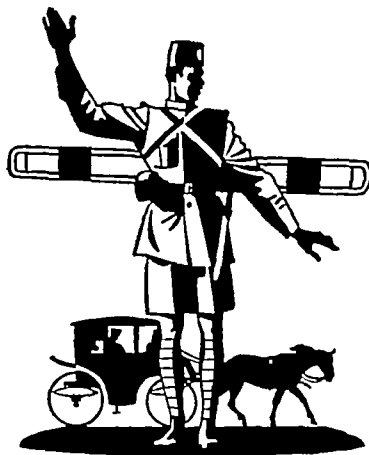
No evidence is available to indicate that multiple carcinomas of the large intestine impose any special therapeutic problems as far as the technique of surgical resection is concerned. The problem is diagnosis. It is suggested that roentgenologic examination is indicated in *all* patients with neoplasms of the large intestine in order to establish the solitary nature of the lesion and the presence or absence of adenomatous polyps within the limitations of the method. It is entirely possible that the incidence of multiple carcinomas of the large intestine observed in this series is too low. Perhaps some of the late recurrences represent new cancers.

SUMMARY

Multiple carcinomas of the large intestine were found in 21 of 726 patients with cancer of that organ. The lesions were more frequently synchronous than metachronous. Roentgenologic examination and exploratory laparotomy were effective procedures for detecting the multiple carcinomas. Adenomatous polyps of the large intestine were associated with multiple carcinomas in only eight of the patients. This is more than twice the incidence of polyps associated with single carcinoma of the colon or rectum.

REFERENCES

1. Warren, S., and Gates, O. Multiple Primary Malignant Tumors, *Am J Cancer* 16: 1358, 1932.
2. McKenny, D. C. Multiple Polyposis. Congenital, Heredofamilial, Malignant, *Am J Surg* 46: 204, 1939.



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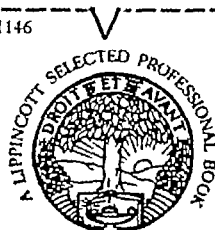
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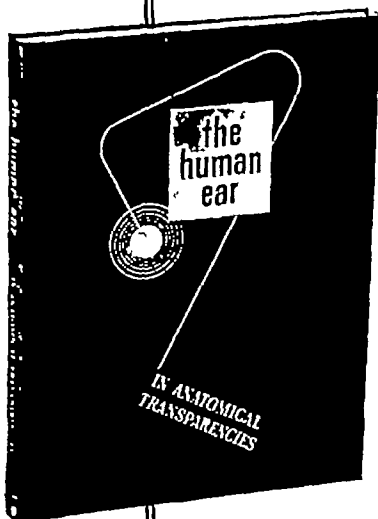
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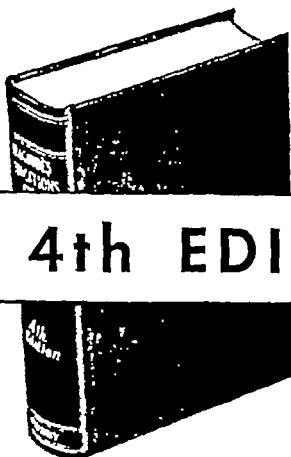
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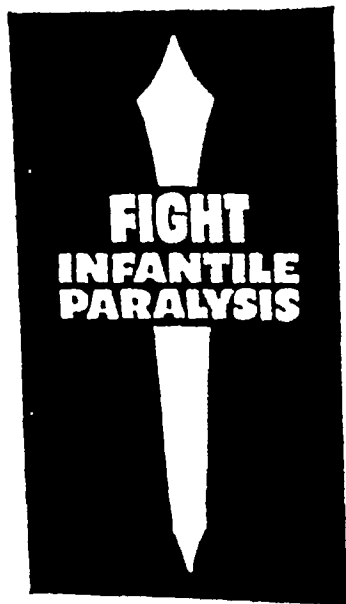


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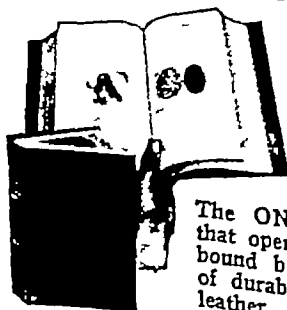
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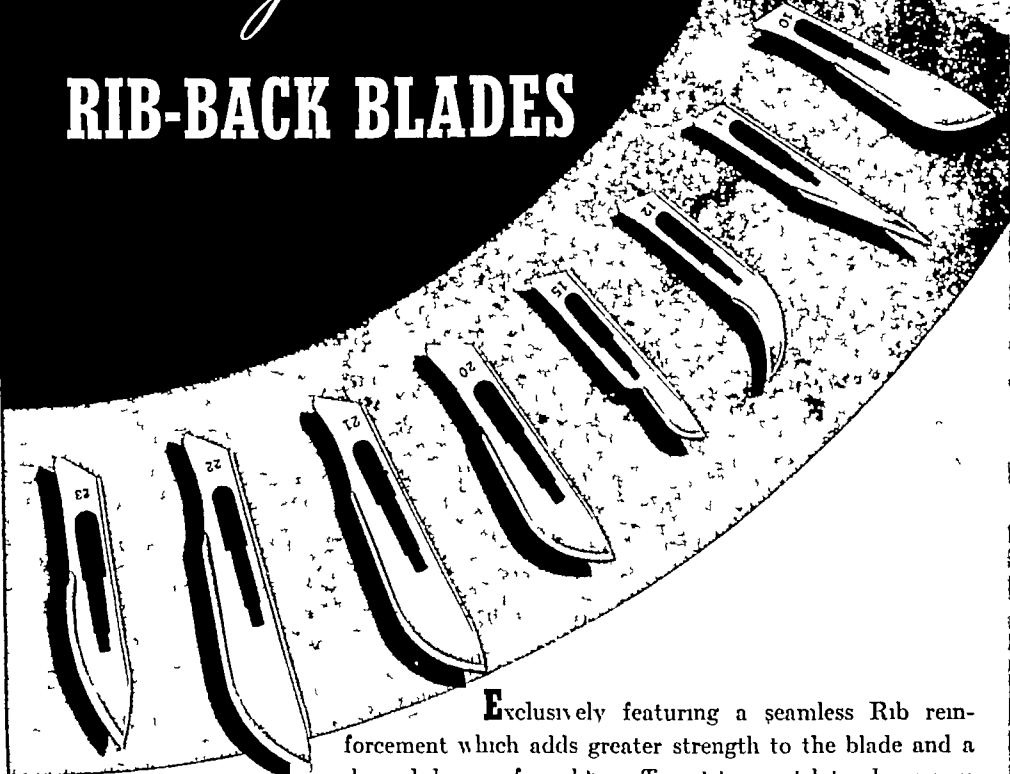
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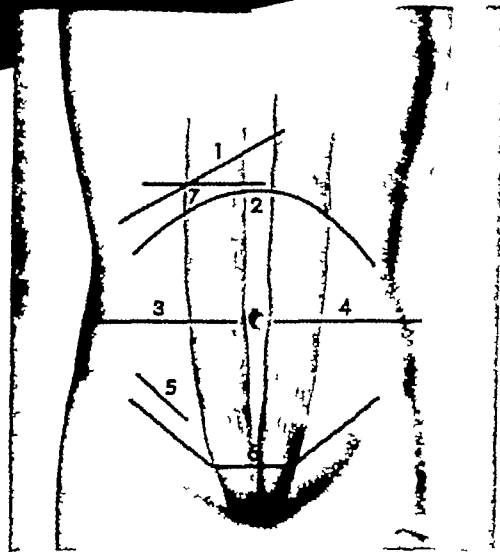
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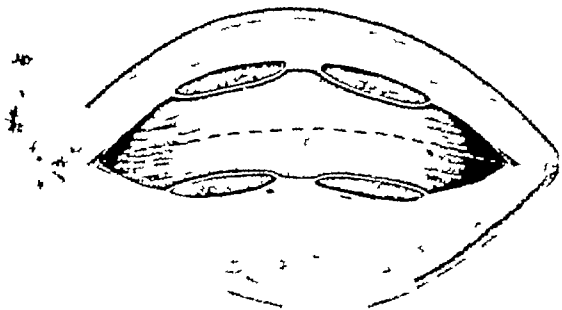
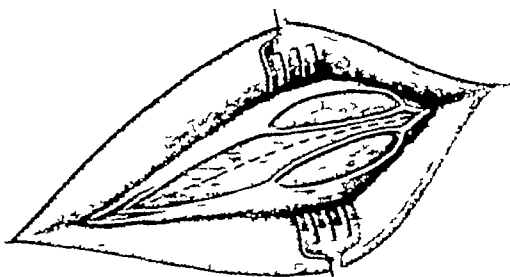
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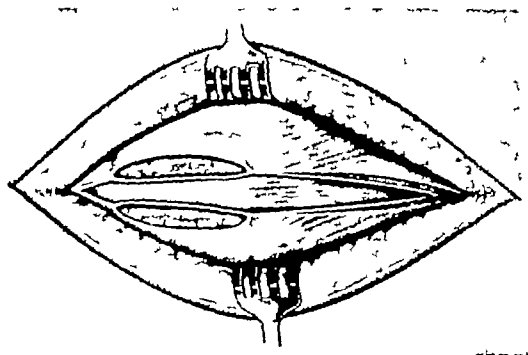
ADVANTAGES OF TRANSVERSE INCISIONS

SUTURES hold more securely if the connective tissue layers within the wound are approximated in such a manner that the sutures must pull against the fibers within them. Sutures pull against the fibers only when the connective tissues are cut parallel to the direction of the fibers. In the anterior abdominal wall, this is usually best accomplished through a transverse incision. As a result, sutured transverse incisions are stronger than sutured vertical incisions.

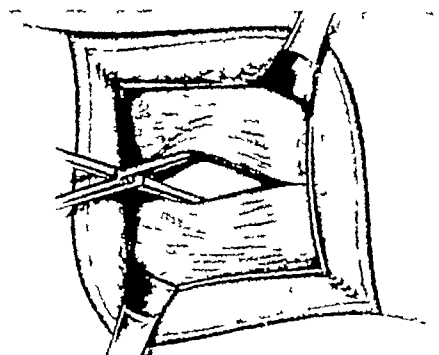
In the past, transverse abdominal incisions did not find a wide acceptance

because they necessitated cutting across muscle. Attempts were made to suture the muscles and the sutures not only held poorly, but they almost invariably caused necrosis.

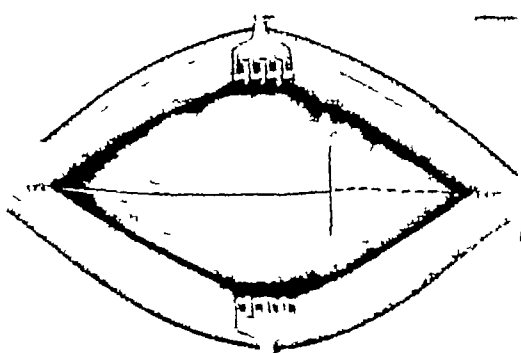
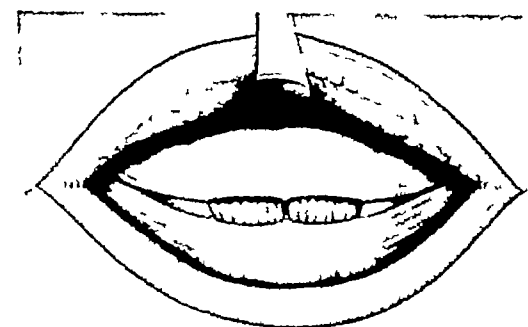
In the new technic, no attempt is made to suture muscles—only the surrounding sheath. Necrosis is thereby avoided. Some approximation of muscle is obtained by suturing their sheath, and further approximation is accomplished by keeping the patient in a semi-reclining position with knees partially flexed.

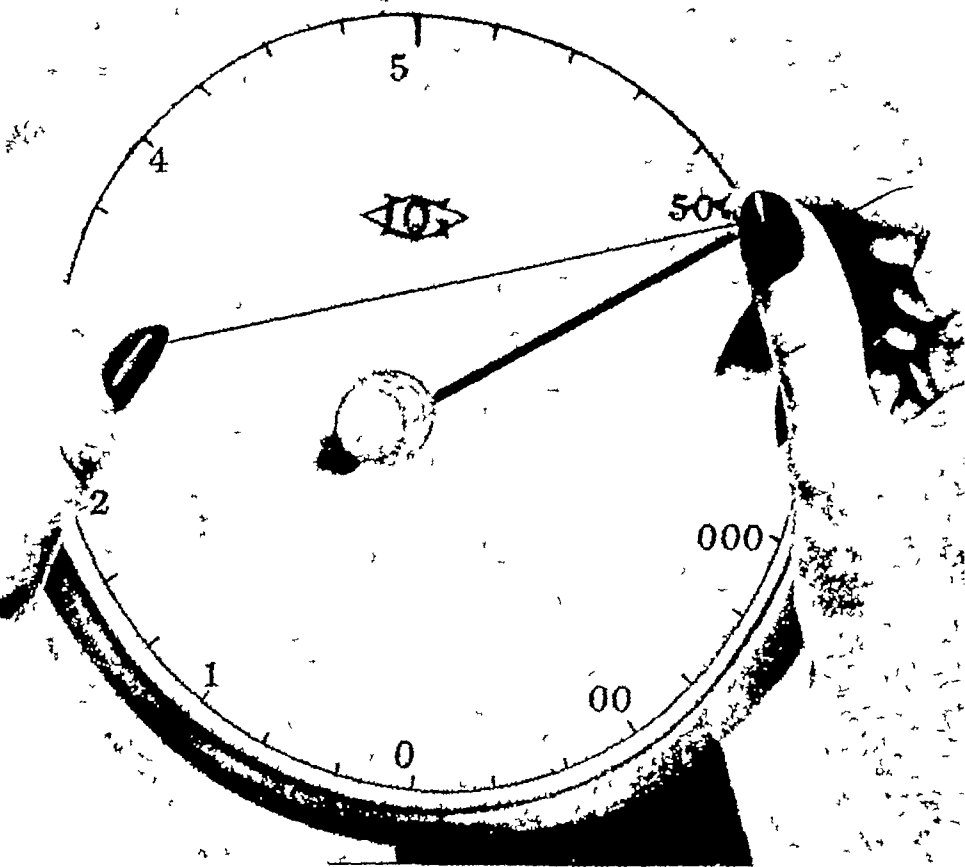


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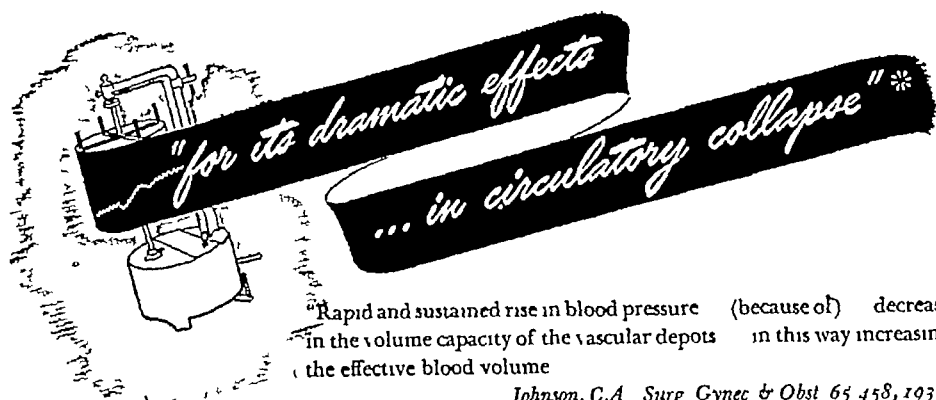
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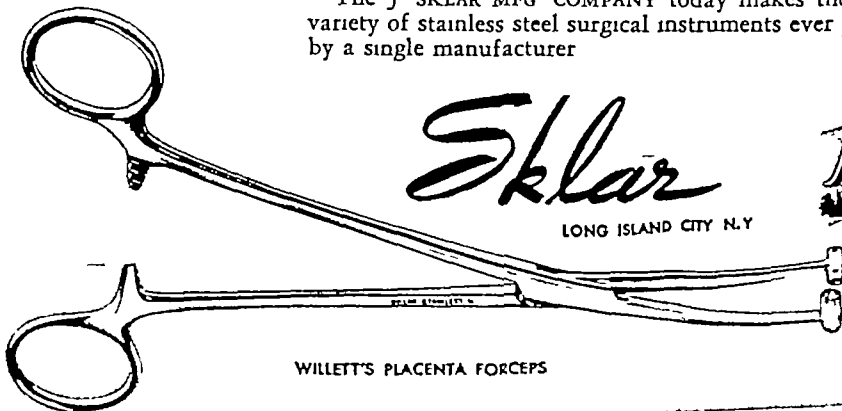
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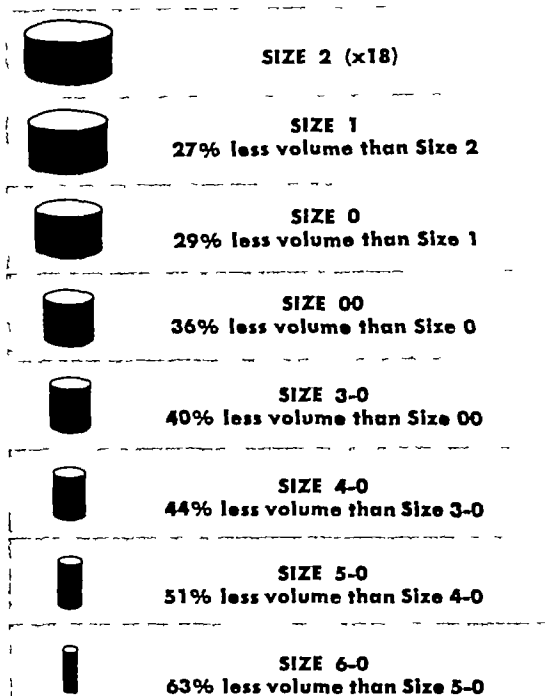
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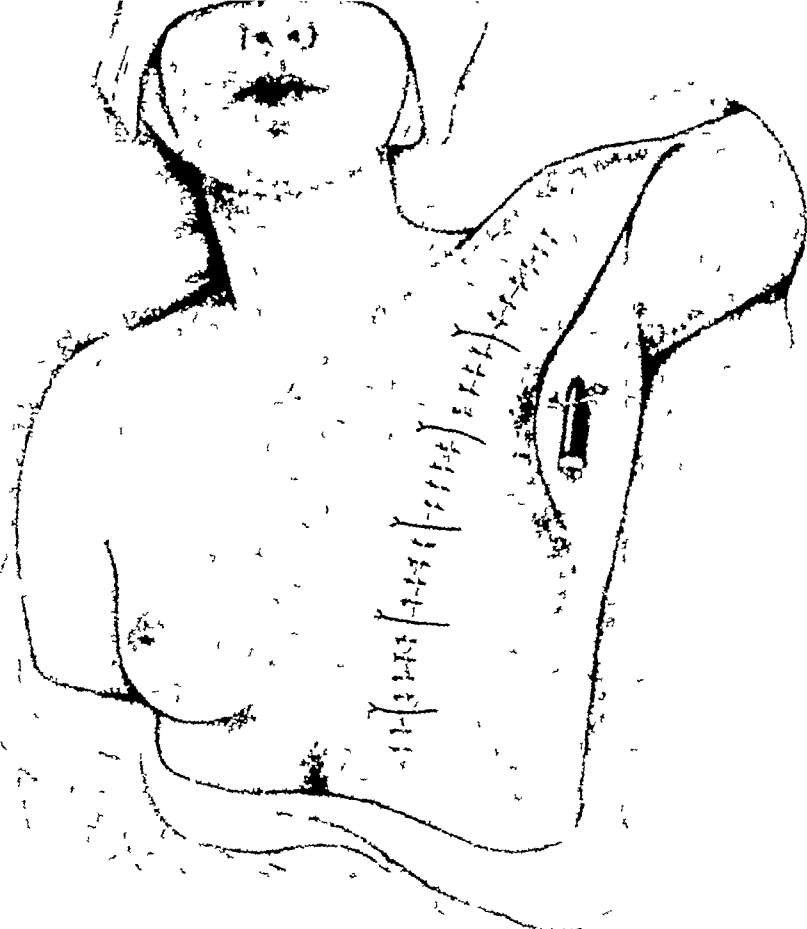
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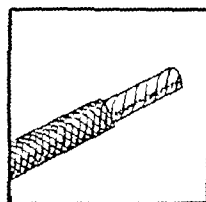


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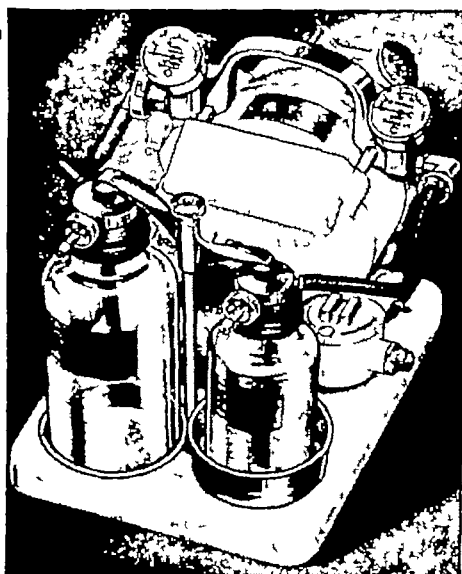
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The present communication is concerned with an analysis of 706 cases of various types of infection (Table I) and represents the cumulative experience of the thirty Army hospitals which participated in the streptomycin investigation from the institution of the program in August, 1945, to the present time.

TABLE I SUMMARY OF STREPTOMYCIN TREATED PATIENTS IN U S ARMY HOSPITALS

	NUMBER OF CASES	RESULTS OF THERAPY		
		IMPROVED	UNIMPROVED	DIED
Urinary infections	364	141	218	5
Wound infections	179	72	105	2
Colitis	34	21	9	4
Peritonitis	30	24	3	3
Bacteremia	16	13	2	1
Meningitis	7	5	0	2
Tuberculosis	15	4	9	2
Brucellosis	13	2	11	0
Typhoid fever	6	3	2	1
Tularemia	2	2	0	0
Others	40	27	12	1
Total	706	314	371	21

METHODS OF ADMINISTRATION AND DOSAGE

Streptomycin salts (hydrochloride, sulfate) are dispensed as fine light yellow powders, in the dry state, in vials containing 1 Gm (1,000,000 S units), 0.5 Gm (500,000 S units), or 0.25 Gm (250,000 S units). For administration, the drug is dissolved in physiologic salt solution, usually to make a 10 per cent solution. Streptomycin solutions are thermostable, and neither the powder nor the solutions show appreciable loss of potency at room temperature for periods of one month. It is well, however, to store solutions in the refrigerator when not in use.

The intermittent method of intramuscular administration has been most commonly employed and is considered preferable. With intermittent therapy there is a supplementary peak of streptomycin well above the constant maintenance level, this may be of therapeutic value and may assist the penetration of streptomycin into relatively avascular tissue. The deltoid, gluteus, and thigh muscles are best suited for the injections, and it is advisable to rotate the doses between the sites. The average duration of treatment and the total dosage

will vary with the individual case and the response to treatment. Some patients were successfully treated with a dose as low as 125 mg (125,000 S units) every three hours by intramuscular injection. It was, however, only with doses of 300 to 500 mg, given every three or four hours, that the results became more consistent. Four hundred milligrams given intramuscularly every four hours produce a maintenance serum level of 16 μ g (S units) per cubic centimeter and a mean urinary level of 1,000 μ g (S units) per cubic centimeter. Renal insufficiency raises the serum level and retards the urinary excretion. The intravenous method of administration has no advantage over the intramuscular method and may produce a dangerous fall of blood pressure. It is not recommended.

Because it does not diffuse readily into the meninges, the pleura, and the bowel, streptomycin has been employed locally to provide effective concentrations in infections involving these tissues. In the meninges and in the pleura, 50 to 100 mg, dissolved in isotonic saline solution, are instilled once or twice daily. This is in conjunction with parenteral administration in the aforementioned doses. For enteric infections, streptomycin is dissolved in water and is administered orally in 2 to 4 Gm daily doses, given at six-hour intervals.

For local or topical use, streptomycin has been employed in various media, using concentrations of the drug equivalent to 2.5 to 5 mg per cubic centimeter or gram of medium. In general, this method of administration is not considered of much value except under certain circumstances discussed later.

The methods of administration and dosage employed in the cases analyzed have followed the principles just described, unless otherwise specified in the special categories to be considered.

URINARY TRACT INFECTIONS

Patients with urinary tract infections (Table II) represent the largest single group treated with streptomycin and account for more than 50 per cent of the total number. The explanation of the high incidence is the large number of paraplegic patients under treatment in Army hospitals and the high proportion of urinary tract infections associated with paraplegia. Mixed infections were the rule in these cases (Table III). Of the presenting bacteria, aerogenes, coli, and Friedlander's organisms were most consistently eradicated. The urinary tract was usually sterilized of the remaining bacteria if conditions were suitable, but larger dosages of streptomycin were required.

The disproportion in the results obtained with streptomycin in the paraplegic and nonparaplegic groups is striking but readily explained. Para-

TABLE II STREPTOMYCIN THERAPY IN INFECTIONS OF THE URINARY TRACT

	WITH SPINAL CORD INJURY				WITHOUT SPINAL CORD INJURY			
	NUMBER OF CASES	IM PROVED	UNIM PROVED	DEATHS	NUMBER OF CASES	IM PROVED	UNIM PROVED	DEATHS
Without calculi	160	56	104	0	98	68	29	1
With calculi	47	5	41	1	26	4	20	2
With abscess or cellulitis	14	1	13		10	1	8	1
Total	221	62	158	1	134	73	57	4

TABLE III INCIDENCE OF AEROBIC PATHOGENIC BACTERIA IN URINARY TRACT INFECTIONS (355 CASES)

	NUMBER OF TIMES RFCODFD	PERCENTAGE
<i>Aerobacter aerogenes</i>	170	25
<i>Escherichia coli</i>	132	19
<i>Proteus vulgaris</i>	115	17
Nonhemolytic streptococcus	83	12
<i>Pseudomonas aeruginosa</i>	70	10
<i>Staphylococcus aureus</i>	58	9
<i>Klebsiella pneumoniae</i>	32	5
Hemolytic streptococcus	20	3
Total	680	100

plegic patients present conditions unfavorable for permanent cure. They have open wounds, residual urine, and ureteral refluxes, and their treatment necessitates the use of tubes and catheters. Under the circumstances any beneficial effects of therapy are likely to be neutralized rapidly because of the unusual opportunities afforded for reinfection or reactivation of the infection after the drug is discontinued. Many patients listed as unimproved showed symptomatic and clinical improvement as long as streptomycin therapy was continued.

In Table II it is suggested that calculi or other obstructive lesions and undrained abscesses also militate against effective streptomycin therapy. They are inaccessible or resistant foci and, in order to prevent the rapid development of drug-fastness, streptomycin is contraindicated until they are collected from the standpoint of relief of obstruction.

There were 5 deaths in the 364 patients with urinary tract infection. Two patients had bilateral urinary calculi, in one instance of the staghorn variety, had been ill for many months, and presented marked malnutrition, cachexia, anemia, and urinary sepsis. The third patient had paraplegia with extensive abscesses of the renal cortex. The fourth had a retrovesical abscess which ruptured into the peritoneal cavity, producing generalized peritonitis. The fifth patient, who had chronic pyelonephritis, died on the tenth day after the institution of streptomycin therapy, apparently of hepatitis, which had been present for several months, and of terminal bronchopneumonia. He was in extremely poor condition, with severe cachexia, anemia, and sepsis, when treatment was begun. All five patients received adequate amounts of streptomycin.

Especially interesting is the small but highly significant group of nine cases of urethritis included in this series (Table IV). Of particular importance is the fact that in all five cases of gonococcal origin, prompt clinical improvement and apparent cure were obtained with streptomycin, although all the patients had previously been treated with adequate dosages of sulfadiazine and penicillin without success.

TABLE IV STREPTOMYCIN THERAPY IN URETHRITIS

TYPE	NUMBER OF CASES	IMPROVED	UNIMPROVED
Nonspecific	4	1	3
Gonorrheal	5	5	0

Analysis of these cases of urinary tract infection seems to show quite clearly that streptomycin is a very useful agent in infections produced by bacteria susceptible to the drug if they are not associated with obstruction, retention of residual urine, and undrained or unsterilizable foci. In other words, the successful use of streptomycin in urinary tract infections depends upon a normal flow of urine. Moreover, the drug must be used early and in adequate dosages, particularly with infections due to the enterococcus and pseudomonas, since habituation of the organism occurs rapidly and is a constant feature of cases in which the concentration of streptomycin in the urine is inadequate. It would also appear that streptomycin may be a highly useful therapeutic agent in gonococcal infections, especially those which prove resistant to penicillin and sulfadiazine.

WOUND INFECTIONS

Wound infections, which numbered 179, represent the second largest category of cases. All the wounds were combat-incurred and most of them were associated with chronic osteitis and fibrosis and impoverished local circulation. Polymicrobial flora were usually present, staphylococci and streptococci being almost invariably identified, with Clostridia present in about one-third of all cases. A variety of gram-negative bacteria of the fecal type were associated, including proteus, coli, Pseudomonas, and aerogenes.

Various combinations of systemic and topical administration of the drug were employed, no vehicle for topical application being completely free of clinical objections. Complete sterilization of the wound was rarely achieved. Extensive fibrosis of soft tissue and sclerotic changes in bone reduce vascularity and lessen permeability so that sufficient contact of the streptomycin with the causative organism must occur infrequently regardless of route of administration. Probably of even greater importance in contraindicating the local use of streptomycin or any chemotherapeutic agent in wound management are such factors as the inevitable discharge of wound secretions and microscopic sloughs offering a medium for the growth of air-borne contaminants, the presence of wound recesses and pockets, the repeated occurrence of small blood clots incident to wound dressing, and the locally destructive effects of retained products of suppuration.

Of the 179 cases in this series, 72 patients (40 per cent) were listed as improved while the remainder were definitely not benefited by streptomycin therapy. Of those listed as improved, however, careful review of the records showed that the improvement was, in most instances, coincident with apparently adequate wound revision. Accordingly, it is quite evident that streptomycin does not differ in any way from other chemotherapeutic agents with regard to its place in the management of wound infections. Adequate surgery, supplemented upon indication with specific chemotherapy, is still the chief therapeutic measure under these circumstances.

There were two deaths, one due to an error in intravenous technique, the other to a ruptured retroperitoneal abscess, neither could be attributed to streptomycin therapy.

TABLE VII STREPTOMYCIN THERAPY IN TUBERCULOSIS

TYPE	NUMBER OF CASES	RESULTS		
		IMPROVED	UNIMPROVED	DIED
Renal	7	2	5	
Pulmonary	4	1	3	
Meningeal	3	1		2
Cutaneous	1		1	
Total	15	4	9	2

origin, in which the course is usually rapidly downhill. Since the patient with pneumonia improved promptly after streptomycin therapy was begun, it seems fair to assume that treatment in this instance was lifesaving, although whether arrest of the disease was due to control of the tuberculosis or to effective inhibition of secondary invaders it is not possible to say. The other patient who showed striking improvement had tuberculous meningitis and at the time of this writing, three months after treatment, has clear spinal fluid and no evidence of reactivity. The two deaths in the series, however, occurred in patients with tuberculous meningitis. There was no improvement in the one patient with cutaneous tuberculosis.

The nine surviving patients in the series who showed no improvement may have received inadequate therapy, in respect to either dosage or duration, or had organisms with natural or acquired resistance, or inaccessible foci. Some of these factors contributed to failure in all cases, while in a few cases all seemed operative.

This series is obviously too small to permit conclusive statements concerning the efficacy of streptomycin in tuberculosis. It seems fair to say, however, on the basis of the striking improvement that followed the use of streptomycin in a few of the cases, that further and more intensive studies in the use of streptomycin in tuberculosis are warranted.

BRUCELLOSIS

In four of the thirteen patients with brucellosis treated with streptomycin, positive blood cultures were obtained. In the remainder, diagnosis was based on high titer agglutinins in the blood, or strongly positive brucellergen skin reactions, or both. Two of the patients had fairly prompt remissions after treatment and their blood cultures became negative. Brucellosis, however, is characterized by remissions, and the follow-up has not been long enough to justify any statement of results. In the remaining eleven cases neither the symptoms nor the course of the disease seemed influenced by therapy.

It is doubtful whether streptomycin, regardless of the dosage employed, can penetrate foci of infection in brucellosis. It is doubtful, also, that treatment by this means is justified in any case, except possibly in the acute phase of the disease.

MENINGITIS

In the seven cases of nontuberculous meningitis treated with streptomycin, the etiologic agents were variously *Aerobacter aerogenes*, *Escherichia coli*

Haemophilus influenzae, hemolytic streptococcus, *Pseudomonas aeruginosa*, and *Staphylococcus aureus*, *Proteus vulgaris*, and *Cryptococcus hominis*. Five patients recovered and two died. One, who had an infection with *A. aerogenes* secondary to laminectomy, was moribund when streptomycin was first administered and was treated only 9½ hours. The other had an infection with *C. hominis*, which is insensitive in vitro to streptomycin as well as to penicillin and sulfadiazine.

The results in this small group of cases, therefore, suggest that streptomycin is a valuable therapeutic agent in meningitis. It is imperative, however, (1) that the organisms be of proved sensitivity, and (2) that the drug be introduced directly into the cerebrospinal circulation.

TYPHOID FEVER

Of six patients with confirmed typhoid fever, three improved, two of whom showed brilliant results. In both, treatment was instituted within two weeks of the onset of symptoms. The third patient, who had a bacteremia, apparently secondary to osteomyelitis due to *Eberthella typhosa*, had good results from a combination of streptomycin and appropriate surgery. Of the remaining three patients, two were carriers with positive stool cultures and no permanent benefits from streptomycin therapy. One patient died, after fourteen days of therapy in adequate dosage, of generalized peritonitis following perforation of a typhoid ulceration of the ileum.

The sharp contrast between the good results of treatment in the acute stage, and the poor results in the chronic stage, of the disease suggest that when once the infection has localized, the foci are not sterilizable and success is not likely to occur.

TULAREMIA

Of two patients with proved tularemia, one, whose disease was of the pneumonic type, responded promptly and dramatically to streptomycin. The other, whose disease was of the ulceroglandular type, required two weeks of treatment before resolution occurred. The results in these two patients support the published observations that streptomycin promises to be a potent therapeutic aid in the treatment of tularemia.

PLEUROPULMONARY INFECTIONS

Of the nine patients in this group, five had pneumonia and four empyema. In the five cases of pneumonia the etiologic agent was recorded as *K. pneumoniae* (Friedlander's bacillus, *Bacillus mucosus capsulatus*) in two cases, and as pneumococcus of undetermined type in the third case. The fourth case presented a mixed infection and in the fifth case culture was not reported. All the patients showed improvement. The organisms isolated were sensitive in vitro to streptomycin and the results of therapy were most encouraging.

Of the four patients with empyema, three improved and one died of generalized sepsis of peritoneal origin. It seems important to emphasize the fact that in all of the cases in which improvement occurred the drug was employed in conjunction with adequate surgical drainage.

OTITIS EXTERNA

The six cases in this group all presented polymicrobial flora, including gram-positive and gram-negative varieties. All cases were treated by local measures, chiefly by wicks saturated with streptomycin solution and renewed two to four times daily. Improvement followed in all but one case, in which the organisms were insensitive.

MASTOIDITIS

In all three cases of mastoiditis the infection was polybacterial, due to *A. aerogenes*, *Staph. aureus*, *P. vulgaris*, and *Ps. aeruginosa*. Two patients showed improvement and one did not. The results were not striking in any case, and such improvement as did occur was possibly coincident with the establishment of adequate drainage.

BRAIN ABSCESS

Two of the four cases of brain abscess were due to penetrating wounds, one was due to pansinusitis, and one was of undetermined origin. The etiologic agents were *Staph. aureus* in two cases with *Ps. aeruginosa* associated in one, *P. vulgaris* in the third case, and anaerobic hemolytic streptococci and anaerobic gram-negative bacilli in the fourth case.

Three patients were improved, although in each case improvement was secured only when parenteral administration was supplemented by drainage of the abscess and local instillation of streptomycin after evacuation of pus. It would seem that the systemic administration of streptomycin can achieve little in this type of case unless it is supplemented by local administration, perhaps because the circulation does not permit the concentration of effective levels of the drug in abscesses. The fourth patient showed no improvement, perhaps because bony and metallic foreign bodies were not removed from the wound.

MISCELLANEOUS CASES

Eighteen cases of various conditions were placed in this category. Four were instances of cutaneous disease. One case of blastomycosis and another of pemphigus showed no improvement. In the other two cases, one of generalized furunculosis and one of acneiform ulceration, neither of which had responded to penicillin, improvement was recorded.

In one case of acute cholecystitis, streptomycin therapy was employed in adequate dosage, 30 Gm. over a period of sixteen days, without striking results. Improvement occurred in this case only after cholecystectomy was performed.

One case of Hodgkin's disease terminated fatally. Streptomycin was administered for seven days prior to death, apparently as a "panic" measure.

One patient with liver abscess, in which the etiologic agent was an anaerobic nonhemolytic streptococcus, showed improvement only after surgical drainage was instituted. It is doubtful that streptomycin was of much value.

The remaining eleven cases in this group were localizing soft-part infections of various kinds. Improvement was recorded in six and no improvement in five cases. All the unimproved cases were associated with insensitive bacteria, inadequate surgery, or inadequate drug therapy.

REACTIONS TO STREPTOMYCIN

The reactions reported following the systemic administration of streptomycin are shown in Table VIII. The greatest number was in the form of headaches, joint pains, and skin reactions, which, while annoying, were transient, disappeared on withdrawal of the drug, and usually responded to symptomatic treatment. Histamine-like reactions, manifested chiefly by a fall in blood pressure, are uncommon with batches of streptomycin now available. The effects of streptomycin on the kidney, manifested by proteinuria, cylindruria, and hematuria, and occasional azotemia, disappeared on withdrawal of the drug. On the basis of these experiences the renal irritation effect of streptomycin should not be regarded as a cause for interruption of therapy, if the kidneys are normal. The two cases of vestibular disturbance were the only instances of serious toxicity, producing permanent damage, associated with streptomycin therapy. Whether additional cases occurred and were not recognized, or were adequately compensated for, is difficult to determine. A more careful and systematic investigation of this complication is now in progress. Vestibular disturbance is the only complication presently considered to be an indication for termination of drug therapy.

TABLE VIII REACTIONS TO STREPTOMYCIN IN 706 TREATED PATIENTS

	NUMBER OF CASES AFFECTED	PER CENT OF TOTAL
Headaches, severe	39	5.5
Skin reaction—urticaria, local or generalized rash, eosinophilia, fever	30	4.2
Arthralgia, generalized	30	4.2
Dizziness	20	2.8
Anorexia, nausea and vomiting, abdominal pain	11	1.6
Alterations in urine albumin, casts, W.B.C., R.B.C.	11	1.6
Blood pressure, fall in (20 mm)	10	1.4
Vestibular disturbance	2	0.28

SUMMARY

1 An analysis is presented of the experience with streptomycin therapy in thirty United States Army hospitals during the period August, 1945, to May, 1946, inclusive. The analysis is based upon 706 cases of infections of various kinds, in all of which complete records were made and submitted to the Office of the Surgeon General.

2 In the treatment of these cases, streptomycin was administered parenterally, locally, orally, or in combination, depending on the type of infection. For systemic administration, the intermittent intramuscular method is preferred. The dosage employed ranged from 1 to 3 Gm. per day, given at three or four hourly intervals. The larger doses generally proved to be more effective. In meningitis and empyema, doses of 50 to 250 mg. in sterile isotonic saline solution, administered once or twice daily into the spinal canal or pleural cavity, were used. For topical application, concentrations of 2.5 to 10 mg. per gram of medium were employed. The oral route was used in enteric infections with a total of 2 to 4 Gm. daily, given in divided doses, every six hours.

3 Systemic administration of streptomycin in the doses cited was found to maintain therapeutically effective levels in blood and urine. Intrathecal and intrapleural administration proved essential for the effective treatment of infections involving the meninges and pleura, respectively. In enteric infections, the drug must be given orally. In most infections the combined route of administration was found essential. Topical use of streptomycin has not been attended by strikingly beneficial results, and in most cases proved to be of little value.

4 In urinary tract infections due to susceptible bacteria, streptomycin has proved to be a very useful agent. Its successful use, however, depends upon a normal flow of urine. Recurrent urinary tract obstruction, urinary retention, and undrained or unsterilizable foci, including the prostate, predisposed to relapse or reinfection. Treatment under these circumstances produced rapid and irreversible drug-fastness.

5 Streptomycin would appear to be a highly useful agent in gonococcal urethritis, especially in those cases which prove resistant to penicillin and sulfadiazine.

6 Relatively extensive experience with streptomycin in wound infections showed that this agent is effective only as an adjunct to adequate surgery, and differs in no way from other chemotherapeutic agents with regard to its place in the surgical management of these conditions.

7 In enteric infections caused by specific, streptomycin-susceptible organisms, the results of treatment are likely to be impressive. In nonspecific ulcerative colitis no substantial benefits have been demonstrated.

8 In this experience, streptomycin in peritonitis did not produce dramatic results.

9 In bacteremia due to streptomycin-sensitive organisms, highly impressive results were obtained. Essential to success, however, is eradication of the focus by surgical means when necessary.

10 Experience with tuberculosis was too small to permit definitive statements, but on the basis of the striking improvement that followed the use of the drug in a few of the cases, more intensive studies are warranted.

11 It is doubtful whether streptomycin therapy is of any value in brucellosis, except possibly in the acute phase of the disease.

12 In nontuberculous meningitis, due to sensitive organisms, streptomycin is a valuable therapeutic agent.

13 In typhoid fever, streptomycin would seem highly effective in the acute state, but after localization has occurred, the beneficial effects were much less evident.

14 In tularemia, streptomycin appeared to be the most effective chemotherapeutic agent presently available.

15 In other infections in this series, the experience was too small to permit conclusive statements concerning the therapeutic usefulness of streptomycin. It is noteworthy, however, that no striking results were obtained in those cases which are commonly considered surgical infections.

16 Vestibular disturbance was the only serious complication to streptomycin therapy, and is the only one presently considered to be an indication for termination of therapy.

BLOOD LOSS IN OPERATIONS A STATISTICAL COMPARISON OF LOSSES AS DETERMINED BY THE GRAVIMETRIC AND COLORIMETRIC METHODS

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OWEN H WANGENSTEEN, M D, MINNEAPOLIS, MINN

*(From the Departments of Surgery and Biostatistics of the Medical School of the
University of Minnesota)*

THE replacement of blood lost during surgical procedures by either whole blood or plasma has become standard practice in the various surgical clinics. Quantitative determination of the blood loss is far preferable to purely subjective estimation, for the errors of personal judgment may reach to dangerous levels. This is particularly the case with the older substandard-risk patient who tolerates large blood loss poorly and who, also, cannot well withstand plethora induced as a result of overreplacement of blood lost in extensive surgical procedures. The best therapy in such patients is replacement both in kind and amount of the fluid lost.

A practical method which permits the surgeon to determine the extent of the blood loss with adequate accuracy while the operation is in progress is highly desirable. Since the advent of newer anesthetic procedures and drugs and increased emphasis on meeting the preoperative nutritional requirements of the patient has made possible more formidable and lengthy surgical procedures, concurrent replacement of blood loss assumes added significance as a factor contributing to success of those procedures.

QUANTITATIVE METHODS FOR BLOOD LOSS DETERMINATION

Various methods have been suggested from time to time for determination of blood lost during surgery. Gatch and Little¹ introduced the acid-hematin method in 1924. This involves washing all the sponges, linen, and instruments free of blood, then adding hydrochloric acid to those washings to make a 0.1 N solution. The acid-hematin preparation thus formed is then compared colorimetrically with a sample of acid-hematin prepared from the blood of the patient before surgery. These authors considered the blood loss so determined should be regarded as a minimum, for the chief error lies in inability to recover all the hemoglobin by washing. The error was stated to be at least 5 per cent. More recent methods have used modifications of this procedure, some introducing the photoelectric colorimeter.²⁻⁵

This entire determination must of necessity be accomplished after the surgery has been completed. Any replacement of blood or plasma that takes place during the operation must be done either as a matter of routine (that is,

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during certain lengthy procedures a specified quantity of blood is automatically started) or on call from the surgeon whose estimate of blood loss determines the replacement. It has been shown that such estimations may be grossly inaccurate.⁶

It has been pointed out by Collier, Crook, and Iob⁷ that there is no correlation between the amount of blood lost and changes in hematocrit, hemoglobin, and plasma protein concentrations before and after operations, and that the patient is benefited most when the blood is replaced as the loss occurs. In procedures such as transurethral resection, it may be practical to use the acid-hematin method to determine the blood loss at any juncture during the operation because the blood is washed directly into a container. However, this is an exceptional situation, it is not normally possible to measure blood loss during the operative procedure by the acid-hematin method.

One of us⁸ pointed out in 1942 the importance of blood replacement during surgery and described the method in use at the University of Minnesota Hospitals to facilitate that replacement in the proper amount. This method is based very simply on the use of dry sponges for collecting blood lost during operation. The circulating nurse in the operating room weighs the used sponges during the course of the operation with sufficient frequency that evaporation from them does not become an item of importance. This procedure permits the surgeon to know the extent of the loss at any stage of the operation. In operations within serous or pleural lined cavities there is some absorption by the sponges of serous fluid which has a protein content of from 2 to 4 Gm per cent. This fluid, which is replaceable, is accounted for in the gravimetric method along with the blood. The complete gain in weight of the sponges is treated as blood loss, each gram being considered as 1 c c.

It might seem that the use of dry sponges would impose a serious handicap on the surgeon. Experience suggests definitely that it does not. Moist sponge packs are employed regularly to cover the intestine to keep fibrin formation on the bowel at a minimum, these sponges are not weighed.

THE PRESENT STUDY

The objective of this investigation has been twofold. First, it has seemed desirable to make a comparison of blood loss as measured by the gravimetric method and the loss as computed from the acid-hematin technique. In addition, an effort has been made to assemble blood loss data for representative surgical procedures as encountered in the University of Minnesota Hospitals, using the gravimetric method.

METHOD OF INVESTIGATION

Gravimetric—A weighing scale (Fig 1) accurate to 1 Gm increments was used in this procedure. Dry sponges are used routinely during operation. These do not have to be weighed before each operation because they are remarkably uniform in weight and come from the autoclave at a constant level of dryness.* The sponges were weighed by a circulating nurse immediately

*Sponges used in this study and their weights are as follows: Curity x-ray 4 by 8 cm 6 Gm. Special sponges 30 by 10 cm, 14 Gm. Ring sponges 28 Gm.

after use to reduce evaporation losses to a minimum. No correction was attempted for the slight departure from unity of the specific gravity of blood, each gram was considered as 1 c.c.

Colorimetric—The sponges used during operation were washed and the colorimetric determinations made postoperatively. The method employed was a modification of the Gatch-Little technique differing in that we used the Evelyn colorimeter in determining the milligrams hemoglobin in an acid-hematin mixture. The blood-soaked sponges are extracted with tap water and the

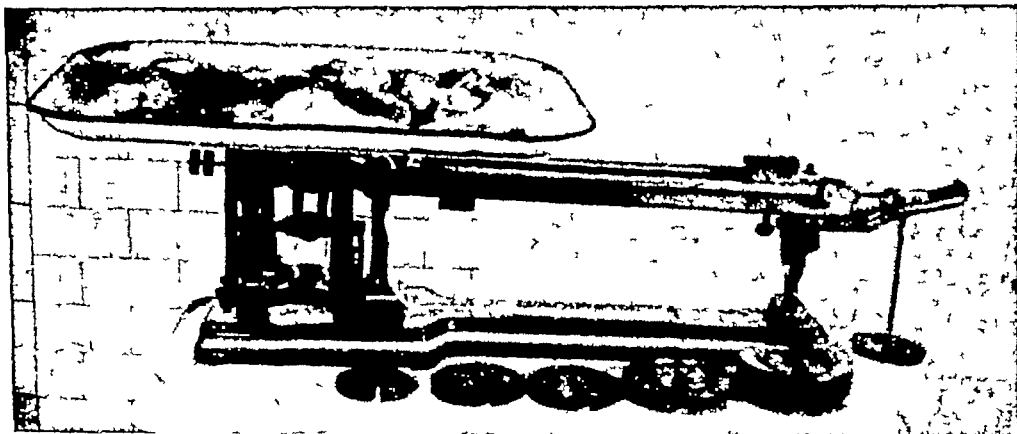


Fig 1.—Use of the weighing scale in determining blood loss during operation. At any juncture the surgeon may know how much blood has been lost. The surgeon must, of course, employ dry sponges. This scale will weigh to an accuracy of 1 Gm.

amount of hemoglobin in a sample of the pooled washings is then determined by interpolating a photoelectric colorimeter reading of the sample in a previously prepared chart. The total amount of blood lost is then computed by the formula

$$100 \frac{(\text{Mg Hb in sample}) \times (\text{Total volume of washings})}{\text{Patient's preoperative Hb}} \text{ c.c.}$$

RESULTS

Comparison of the Gravimetric and Colorimetric Determinations of Blood Loss—Twenty-one surgical procedures were selected arbitrarily for this study. The basic data are summarized in Table I. It will be noted that the majority of the operations were performed within serous or pleural-lined cavities.

The close correlation between the blood loss values yielded by the two methods is shown graphically in Fig 2 where each of the twenty-one dots represents a pair of determinations. The continuous diagonal line in Fig 2 denotes equal values for the gravimetric and colorimetric methods, dots above this line designate cases wherein the colorimetric value was higher, while those below the line show a higher gravimetric value. The horizontal (or vertical) distance from each dot to the diagonal equality line defines the difference between the gravimetric and colorimetric determinations for each case.

It is quite apparent from Fig 2 that higher colorimetric values are few in number, are small in margin of difference from the gravimetric result, and are concentrated in the low blood loss region. Sixteen of the twenty-one differences show an excess for the gravimetric measurement, as would normally be expected. In general, these differences increase slightly in magnitude as the blood loss increases. However, the agreement as a whole is remarkably close.

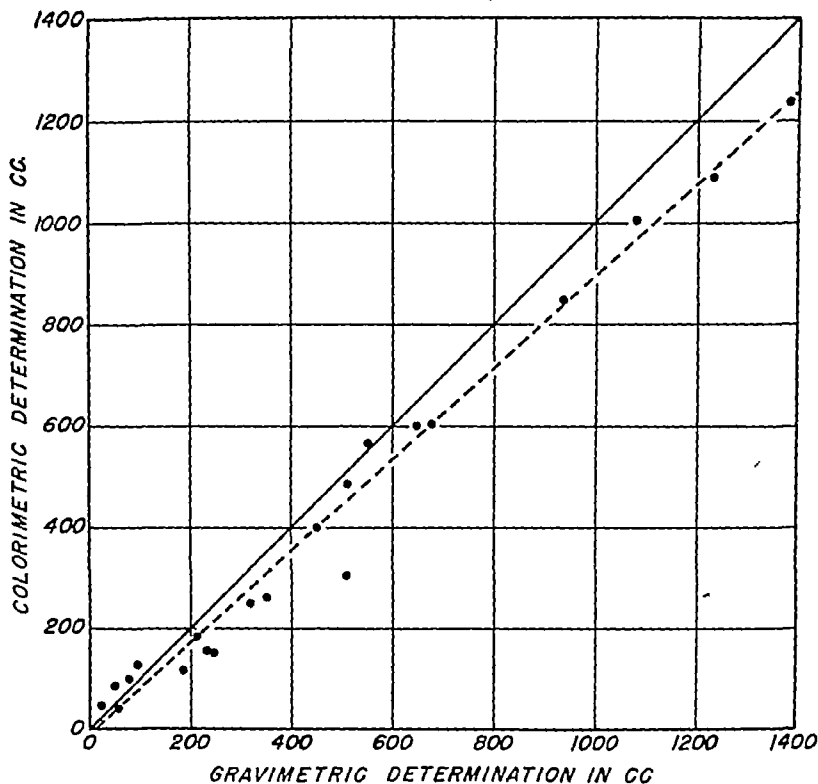


Fig 2—Relationship between gravimetric and colorimetric determinations of blood loss. Continuous diagonal line denotes identical values for the determinations. Interrupted line defines the average colorimetric value for each gravimetric determination.

The interrupted line in Fig 2 indicates the “most likely” or expected average colorimetric value for each gravimetric value. The clustering of the dots above the line* indicates clearly that a straight line average relationship exists between the two methods. The difference between the continuous line and the interrupted line, therefore, portrays the average departure from equality of the two determinations. At low blood losses the difference is quite negligible for practical purposes. Even at high blood loss levels, the differences are not very large.

For all blood losses the colorimetric value, on the average, is very close to being 10 per cent less than the gravimetric value. Since losses in the process

*The equation for this line, as computed from the observed values is

$$C = 19.4 + 1.086G$$

where C = colorimetric and G = gravimetric value. The correlation coefficient for the association is + 0.9905.

TABLE I SHOWING COMPARISON OF GRAVIMETRIC AND COLORIMETRIC DETERMINATION OF BLOOD LOSS

INITIALS	HOSPITAL NUMBER	SEX	OPERATION	PRE-OP HB	BLOOD LOSS		DIFFERENCE
					COLORIMETRIC	GRAVIMETRIC	
E K	744309	F	Gastroenterostomy	13 05	115	187	+ 72
A E	721039	F	Cholecystectomy	12 00	154	247	+ 93
A G	744986	M	Subtotal gastrectomy	14 00	305	509	+204
J O	684731	M	Colon resection	15 60	400	450	+ 50
L S	701020	F	Cholecystectomy	14 00	100	79	- 21
G S	743507	M	Subtotal gastrectomy	11 40	1,240	1,385	+145
W B	736170	M	Cholecystectomy	13 45	605	678	+ 73
S D	746017	M	Pneumectomy	13 05	600	648	+ 48
F D	746167	M	Subtotal gastrectomy	12 85	1,006	1,078	+ 72
H H.	636960	F	Cholecystectomy and choledochostomy	11 30	1,090	1,231	+141
S E	170101	M	Diaphragmatic hernia	13 10	131	93	- 38
A P	744149	M	Gastroenterostomy	12 05	182	210	+ 28
B S	746274	M	Subtotal gastrectomy and colon resection	13 00	850	936	+ 86
G O	744513	M	Splenectomy	13 35	40	58	+ 18
D C	755585	F	Repair of ventral hernia	14 90	83	48	- 35
S F	750187	F	Gastroenterostomy	13 10	48	22	- 26
H W	755258	M	Subtotal gastrectomy	11 90	488	511	+ 23
G J	756362	M	Radical mastectomy	11 80	568	550	- 18
M. S	756210	F	Subtotal gastrectomy	11 70	261	351	+ 90
M W	756379	F	Choledochostomy	12 60	156	233	+ 77
S G	756415	M	Subtotal gastrectomy	14 90	250	319	+ 69
Total					8,672	9,823	1,151

of extraction of blood from the sponges reduce the colorimetric value below what it should be, it is clear that the gravimetric determination cannot be much in excess of the true blood loss. The increment of serous fluid other than blood in the gravimetric determination is obviously only a very small proportion of the total.

Blood Loss in Operations of Various Kinds—The blood losses during consecutive surgical procedures, as determined by the gravimetric method, will now be reviewed.* During appendectomy, blood loss was minimal and averaged 25.8 cc (Table II). Hernia and gall bladder procedures averaged 82.9 and 179.4 cc, respectively (Tables III and IV). Operations on the large bowel do not entail high blood losses (121.5 cc, see Table V). This may be presaged because the major blood supply to the intestine is directly visible and easily approached.

Comparison of the data obtained from subtotal gastrectomy for ulcer and carcinoma (499.8 and 455.6 cc, respectively, see Tables VI and VII) shows

TABLE II BLOOD LOSS IN APPENDECTOMY (GRAVIMETRIC)

INITIALS	HOSPITAL NUMBER	OPERATION	BLOOD LOSS
H B	729569	Appendectomy	35.0
B Y	752284	Appendectomy	34.0
D R	756865	Appendectomy	25.0
A. W	757055	Appendectomy	31.0
H C	757079	Appendectomy	5.0
Average			25.8

*These operations were consecutive and were conducted between Nov. 1, 1944 to Aug. 1, 1945 inclusive.

enlarged goiters in patients with high initial basal metabolic rates provide most of the bleeding. The average blood loss for the diffusely enlarged glands was 668 c c while that for the nodular gland was 206 c c.

TABLE VIII BLOOD LOSS IN SUBTOTAL THYROIDECTOMY (GRAVIMETRIC)

INITIALS	HOSPITAL NUMBER	AGE (YR)	OPERATION	BLOOD LOSS	B M R ON ENTRY	NODULAR OR DIFFUSE GLAND	PER CENT RE SECTED
J H	750144	57	Subtotal thyroidectomy	144	+ 30	Nodular	90
R W	750394	58	Subtotal thyroidectomy	609	+ 75	Diffuse	99
I H	753666	52	Subtotal thyroidectomy	888	+111	Diffuse	99
E A.	753253	61	Subtotal thyroidectomy	578	+ 80	Diffuse	95
L R	753267	67	Subtotal thyroidectomy	212	+ 65	Nodular	95
M L	672614	48	Subtotal thyroidectomy	354	B M R not done	Cancer	50
M R	756181	41	Subtotal thyroidectomy	597	+ 97	Diffuse	95
M A.	756620	44	Subtotal thyroidectomy	228	+ 30	Nodular	90
M S	637953	47	Subtotal thyroidectomy	100	+ 39	Nodular	90
H G	656813	46	Subtotal thyroidectomy	346	+ 37	Nodular	80
Average				405.6			
Average for the diffusely enlarged gland				668.0			
Average for the nodular goiter				206.0			

TABLE IX BLOOD LOSS IN RADICAL MASTECTOMY (GRAVIMETRIC)

INITIAL	HOSPITAL NUMBER	OPERATION	BLOOD LOSS
L E	755438	Radical mastectomy	310
C H	749720	Radical mastectomy	695
A. J	756247	Radical mastectomy	406
N R	750238	Radical mastectomy	196
G J	756362	Radical mastectomy	550
L E	755438	Radical mastectomy	310
A. G	756144	Radical mastectomy	338
I G	756314	Radical mastectomy	350
O W	756118	Radical mastectomy	344
A J	756589	Radical mastectomy	605
Average			415.4

TABLE X. BLOOD LOSS IN PNEUMONECTOMY AND LOBECTOMY (GRAVIMETRIC)

INITIAL	HOSPITAL NUMBER	OPERATION	BLOOD LOSS
F R	752275	Pneumonectomy for carcinoma	1,457
O F	753104	Pneumonectomy for carcinoma	1,444
A. M	747663	Pneumonectomy for carcinoma	1,154
B J	747501	Pneumonectomy for carcinoma	2,124
J M.	749308	Pneumonectomy for carcinoma	1,490
L K.	755181	Left pneumonectomy for bronchiectasis	691
A. A	753762	Lobectomy (right lower lobe and right middle lobe) for bronchiectasis	682
C K.	698525	Right lower lobe and right middle lobe lobectomy for bronchiectasis	1,755
L P	617665	Right upper lobectomy for bronchiectasis	1,470
H K.	749320	Right lower lobe lobectomy for bronchiectasis	1,492
I S	740694	Right lower lobe lobectomy for bronchiectasis	475
M B	749302	Left lower lobe lobectomy for bronchiectasis	995
M B	750600	Left pneumonectomy for bronchiectasis	2,983
P S	752302	Left pneumonectomy for bronchiectasis	1,375
Total average			1,399.0
Carcinoma average			1,534.0

The average loss during radical mastectomy was 415.4 cc (Table IX). Pneumonectomy and lobectomy proved to be procedures during which the blood loss was very high (Table X). This is consistent again with the findings of others. The average for these procedures was 1,399 cc. There was no significant difference between the average obtained for pneumonectomy for carcinoma (1,543 cc) and that for pneumonectomy or lobectomy for bronchiectasis (1,324 cc). As pointed out previously,⁶ there is a good deal of blood lost in making the necessarily long incision.

The figures presented in the foregoing section serve as a guide to the average blood loss of various surgical procedures. In each operation of any magnitude, a 5 per cent solution of glucose is allowed to run slowly into one of the patient's leg or ankle veins from the outset. For blood losses of 500 cc or less, an equivalent amount of plasma is usually adequate. However, it is best to replace blood losses in excess of 500 cc with an equivalent amount of blood. De Gowin and Hardin⁹ suggested that an alkaline urine obtained by the intravenous administration of sodium bicarbonate solution (250 cc of 5 per cent solution) when administering blood may diminish the formation of albuminous casts in the renal tubules attending hemolytic reactions. The clinical evidence on this point, however, is not conclusive.

SUMMARY AND CONCLUSIONS

Gravimetric determination of gain in sponge weight provides a reliable estimate of blood loss in surgical procedures. The extent of such blood loss may be determined as the procedure is progressing without any interference to the surgeon, thus allowing almost concurrent replacement. A reduction of the sponge weight gain by somewhat less than 10 per cent provides an acceptable average correction for other fluids taken up by the sponges, however, replacement of such loss by plasma or blood may be as desirable as for the blood itself. The blood loss in various surgical procedures at the University Hospital is presented.

REFERENCES

1. Gatch, W. D., and Little, W. D. Amount of Blood Loss During Some of the More Common Operations, *J. A. M. A.* 83: 1075, 1924.
2. Pilcher, F., and Sheard, C. Measurements on the Loss of Blood During Transurethral Prostatic Resection and Other Surgical Procedures Determined by Spectrophotometric and Photometric Methods, *Proc. Staff Meet., Mayo Clin.* 12: 213, 1937.
3. Nesbit, R. M., and Conger, K. B. Studies of Blood Loss During Transurethral Prostatic Resection, *J. Urol.* 46: 713, 1941.
4. White, M. L., Jr., and Buxton, R. W. Blood Loss in Thoracic Operations, *J. Thoracic Surg.* 12: 198, 1942.
5. Seves, H. F., and Latchem, C. W. A Table for Determination of Blood Loss During Transurethral Prostatic Resection, *Proc. Staff Meet., Mayo Clin.* 20: 151, 1945.
6. Oppenheim, A., Pack, G. T., Abels, J. C., and Rhoads, C. P. Estimation and Significance of Blood Loss During Gastrointestinal Surgery, *Ann. Surg.* 119: 865-872, 1944.
7. Coller, F. A., Crook, C. E., and Iob, V. Blood Loss in Surgical Operations, *J. A. M. A.* 126: 1, 1944.
8. Wangensteen, O. H. The Controlled Administration of Fluid to Surgical Patients. Including Description of Gravimetric Methods of Determining Status of Hydration and Blood Loss During Operation, *Minnesota Med.* 25: 783, 1942.
9. De Gowin, E. L., and Hardin, R. C. Reactions From Transfusion of Preserved Blood. Experience with 1,600 Transfusions, *Brit. M. J.* 2: 1, 1940.

CHEMICAL ALTERATIONS OCCURRING IN THE SURGICAL PATIENT AND THEIR INTERPRETATIONS

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THE problem of maintaining a sick patient in a state of good nutrition and in water balance is a complex one. Many studies have appeared recently on the alterations of fluid, protein, and electrolytes in various diseased conditions, and it is the purpose of this paper to point out some of the disputed problems and to clarify them if possible.

Accurate chemical methods are helpful in determining the state of electrolyte balance, hydration, or nutrition of sick and injured individuals, but unfortunately most of these determinations are quite complex and time consuming so many workers^{1, 2, 5, 6} have relied on the hemoglobin, cell volume (hematocrit), specific gravity of whole blood and plasma, and the plasma chloride, protein, or albumin concentration. Such determinations can be of great assistance if properly evaluated, but unfortunately may also be misleading and should not be given preference over the patient's history and physical findings.

It should be kept in mind that a low or normal plasma sodium, protein, or chloride concentration can be encountered when a state of dehydration or overhydration exists. It has been stated that the hematocrit may serve as a guide,^{1, 2, 5, 6} but here again so called high, normal, or low values may be noted in the apparently normal individual¹³ or when dehydration¹⁴ or shock¹⁵ is present. Such determinations may at times indicate directional changes in hydration but they cannot be employed as a quantitative measure of it.

Recently, in determining the hematocrit values in fifty-nine apparently normal volunteer male subjects¹³ it was found that the values ranged between 41.8 and 52.4, with a mean hematocrit value of 48.2. Thus, some apparently normal people show values which by the "clinical rules" would be considered abnormal. Varying degrees of anemia may also exist in the sick patient either because of a pre-existing anemia or because of destruction of red blood cells resulting from the injury or illness. It is quite possible then to have a hematocrit of 35 increase to 45 following an injury, but because it appeared to be normal, therapy might be withheld if clinical rules were strictly adhered to.

Several years ago it was shown that various chemical determinations may be normal in cases with intestinal obstruction,¹⁴ carcinoma of the stomach, or pyloric stenosis,¹⁶ and yet the patient may be in a state of malnutrition or dehydration. Marriott¹⁷ earlier emphasized the same fact and Lyons¹⁸ more recently reported results on patients with infection who may also show hemoglobin and plasma protein concentrations which are not indicative of the true

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TABLE I THE DISCREPANCY BETWEEN THE PLASMA PROTEIN CONCENTRATION AND TOTAL CIRCULATING PLASMA PROTEINS

CASE	DIAGNOSIS	MEASURED PLASMA VOLUME (c.c.)	EXPECTED PLASMA VOLUME (c.c.) *	PLASMA VOLUME (PER CENT OF NORMAL)	PER CENT CELL VOLUME (HEMATOCRIT)	PLASMA PROTEIN CONCENTRATION (GM PER 100 c.c.)	PLASMA PROTEIN CONCENTRATION (PER CENT OF NORMAL) †	TOTAL CIRCULATING PLASMA PROTEINS (GM)	EXPECTED TOTAL CIRCULATING PLASMA PROTEINS (GM)	TOTAL CIRCULATING PLASMA PROTEIN (PER CENT OF NORMAL)
1	Carcinoma of stomach	1,640	2,500	66	47	0.10	91	103	175	60
2	Carcinoma of stomach	1,990	2,690	74	38	5.85	84	116	188	62
3	Carcinoma of esophagus	1,870	2,900	64	41	5.46	78	102	203	50
4	Carcinoma of stomach	2,100	2,710	77	44	6.46	92	136	190	72
5	Pyloric stenosis due to ulcer	1,480	2,040	73	37	0.15	88	91	143	64
6	Pyloric stenosis due to ulcer	2,140	2,600	82	40	5.92	85	127	183	69

*Calculated from body surface area

†Seven grams per 100 c.c. was used as the normal plasma protein concentration

Since the normal values for these cases were calculated by employing the surface area there may be some question of their validity. However it should be remembered that the normal plasma volumes were calculated from the surface area by employing the patient's weight in his malnourished state and since these patients lost twenty to forty pounds during their illness the patient's actual normal plasma volume would probably be much greater. For example the second patient lost thirty-five pounds and if his normal weight had been employed in determining the surface area the estimated plasma volume would be approximately 3,100 c.c. and the per cent of normal total circulating proteins would be 63 instead of 62 per cent. Similarly the estimated normal plasma volume for Case 6 is listed as 2,600 c.c. but if the patient's normal weight had been employed in the calculation the expected plasma volume would have been 2,930 c.c. and the total circulating plasma protein 208 Gm instead of 183 Gm.

existing state. Other studies^{17, 20} have also stressed the importance of volume alterations as well as changes in the blood concentration. While at times the plasma volume determination may prove to be a valuable adjunct in the care of patients, it too has its limitations.¹⁸ It has been shown^{13, 21} that an estimated normal plasma volume calculated from the surface area, height, or weight may be in considerable error.

In Table I are shown the results of six previously reported cases.¹⁶ The hematocrit and the plasma protein concentration do not appear markedly lowered. It should be noted, however, that the plasma volume is well below the expected normal range, and that there is a definite reduction in the red cell mass and total circulating proteins which is masked by dehydration. Thus, if the plasma volume were restored to its pre-existing level by the administration of salt solutions, without the addition of protein, there would be a precipitous fall in the plasma protein concentration. Experimental studies²² have demonstrated that under certain conditions the plasma protein concentration may remain normal or fall slightly with a simultaneous increase in the amount of total circulating plasma protein.

In Table II is illustrated the approximate change which would occur in the aforementioned patients if a normal total blood volume or a normal plasma volume were restored without the addition of red blood cells or plasma protein. It is felt that since a precipitous fall in the plasma protein concentration may occur in hemorrhaging or malnourished patients who cannot mobilize additional plasma protein, solutions containing sodium salts should be temporarily withheld or given very cautiously following major surgical procedures.

A significant fall in the plasma protein concentration postoperatively has been shown to occur^{23, 24} in some patients, but in nondepleted or nutritionally normal individuals only a slight change in concentration results even though the extracellular fluid volume is increased, because an adequate amount of protein can be mobilized.^{25, 26}

TABLE II CHANGES WHICH WOULD OCCUR IN MALNOURISHED PATIENTS IF THE PLASMA VOLUMES WERE RESTORED TO NORMAL BY THE ADDITION OF FLUID CONTAINING SODIUM SALTS

CASE	DETERMINED HEMATOCRIT	HEMATOCRIT IF PLASMA VOLUME WERE RESTORED TO NORMAL*	HEMATO- CRIT IF TOTAL BLOOD VOLUME WERE RESTORED TO NORMAL*	DETERMINED PLASMA PROTEIN CONCENTRATION (GM PER 100 CC)	PLASMA PROTEIN CONCENTRATION IF PLASMA VOLUME WERE RESTORED TO NORMAL*	PLASMA PROTEIN CONCENTRATION IF BLOOD VOLUME WERE RESTORED TO NORMAL*
1	47	37	32	6.40	4.20	3.40
2	38	31	33	5.85	4.31	3.12
3	41	31	25	5.46	3.52	2.58
4	44	38	33	6.46	5.02	4.15
5	37	30	27	6.15	4.46	3.21
6	40	35	30	5.92	4.88	3.80

*Calculated on the basis of a return to a normal volume without the addition of red blood cells or plasma protein.

Prolonged anesthesia,²⁷ shock,²⁸ anoxia²⁹ and trauma or injury to the body^{15, 30, 31} may effect the elimination of various solutes and water by the kidneys. The ability to eliminate sodium chloride postoperatively may, therefore, in some instances be impaired. Water and salt retention may also occur in alcoholics³² and in patients with pneumonia,^{33, 34} with a resulting increase in the extracellular fluid volume.³⁵ It has also been noted in patients convalescing from heart failure³⁶ and in subjects with adrenal dysfunction.³⁷ In the seriously ill surgical patient who is given 1 to 2 L. of a salt solution daily, the body may have forced upon it 9 to 18 Gm. of sodium chloride. Normally on such an intake of salt almost all of it would be excreted by the kidneys but when such is not feasible it leads to an increased extracellular fluid volume. Postoperative salt intolerance has been well emphasized^{38, 39} and it has been demonstrated also⁴⁰ that when large amounts of saline are given, sizable quantities of salt may be retained following operations for carcinoma of the colon. Pulmonary, cerebral, or gastrointestinal edema may thus result with serious consequences.

The undesirable effect of large amounts of a saline solution were well reviewed by Trout⁴¹ and later by Matas.⁴² They pointed out the dangers of even a normal salt intake when the kidneys were not functioning properly and presented evidence to show that salt may actually cause renal damage and anuria when given to patients postoperatively.

The excessive administration or retention of water and salt, of course, are not the only factors of importance in the production of edema, but as others have shown^{39, 43, 44} many factors must be considered.

In the studies of Jones, Eaton, and White,⁴⁵ excessive nitrogen catabolism or nitrogen starvation and infection seemed to be the most important factors causing edema in surgical patients, but only when sufficient fluid and salt were available to pass into the affected area.

The formation of edema, either localized or generalized, usually results when one or more of the following causes are present: (1) protein depletion (a reduction in the colloid osmotic pressure especially due to a loss of plasma albumin), (2) increased hydrostatic or filtration pressure, (3) increased capillary permeability (due to anoxia, inflammation, physical agents, or drugs), (4) increased osmotic pressure of the interstitial fluid or decreased tissue elasticity, (5) a temporary or permanent failure of the kidneys to excrete water or eliminate salt due to kidney or endocrine dysfunction, (6) obstruction to the lymphatics, and (7) the overadministration of isotonic or hypertonic salt solution with a resulting shift of intracellular fluid to the extracellular phase. The excretion rate following loading with several different solutions is shown in Figs. 1 and 2. Similar results^{39, 46} were noted by other workers. In the recent work of Collier, Job, Vaughan, Kalder, and Moyer⁴⁷ they emphasized the derangement of the body fluid compartments which may result from improper fluid administration. As they pointed out isotonic salt (0.9 per cent) solutions are not desirable because a greater per cent of the ingested water is eliminated than salt leaving a hypertonic extracellular phase which is then

corrected if no other water is given by a withdrawal of water from the cell Winkler, Elkinton, Hopper, and Hoff⁴⁰ have shown that extreme water depletion can occur within the cell when the extracellular fluid is hypertonic and they believe that under such circumstances death usually results from respiratory failure while the cardiovascular system is little affected It has also been shown³⁹ that large amounts of a half-strength isotonic salt solution (0.45 per cent) produced an opposite effect (that is, the accumulation of more

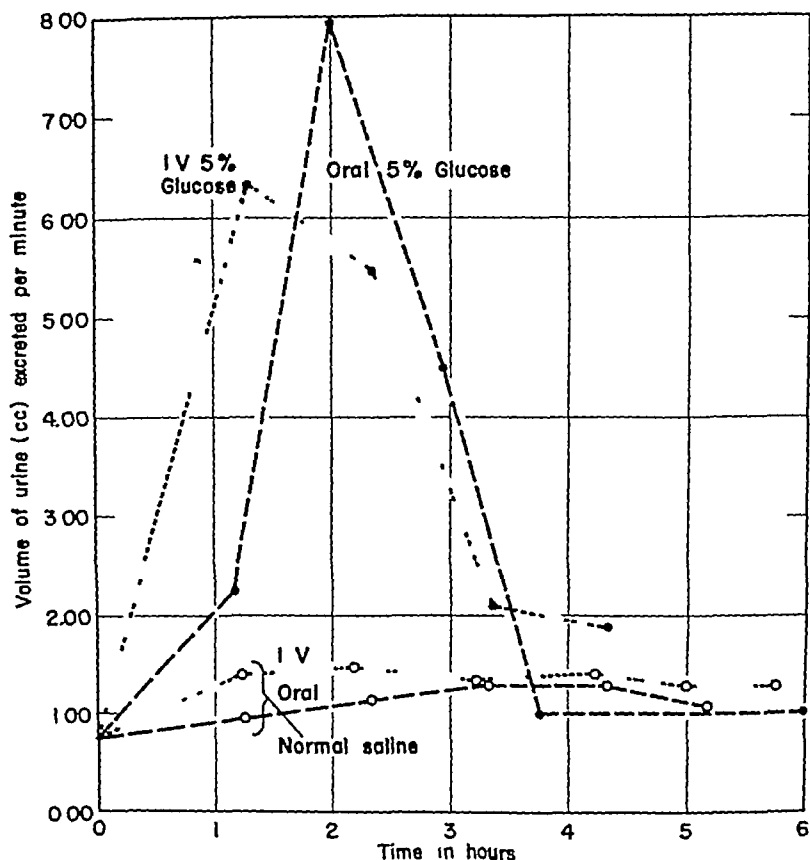


Fig. 1.—The difference in the rate of excretion between the oral and intravenous intake of 1 000 c.c. of 5 per cent Dextrose in distilled water and the oral and intravenous intake of 1 000 c.c. of normal saline solution

water than salt), thus resulting in a hypotonic extracellular phase with a resulting intracellular shift of water The shift of body fluid from one compartment to another because of changes in the amount and concentration of various electrolytes has also been well demonstrated by experimental studies^{47 51}

The most logical method available, at present, of estimating deficiencies in red cells, protein, salts, and fluid is by a careful history and physical examination and a correlation of the important findings with the laboratory data The type of therapy becomes fairly obvious, regardless of the blood chemical determinations when one learns that the particular patient in question has lost

considerable weight, has consumed little food and fluids, has vomited frequently, or has noted bloody or tarry stools. The physical findings of a wrinkled, pale skin, dry-coated tongue, and sunken eyeballs with subnormal tension verify the impressions gained from a careful history.

Some recent publications have intimated that sodium chloride^{6, 8, 9, 12, 52, 58} deficiencies or the state of hydration could be estimated from the plasma chloride concentration. However, experience has taught us that such reasoning is unsound, as was pointed out in 1928 by McIver and Gamble⁵⁴. They have shown that a loss of bile and intestinal fluid may occur with a resulting reduction in the total amount of body electrolytes and fluid without appreciably

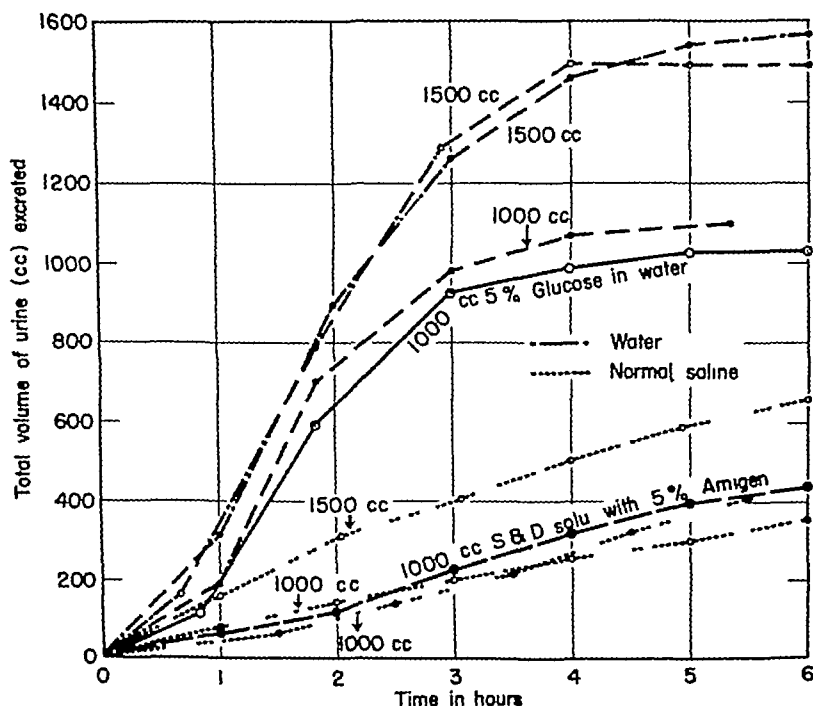


Fig 2—The amount of urine excreted following the oral ingestion of various solutions (The figure near the excretion line shows the amount of fluid ingested at zero time.) The solution which is labeled S & D is a salt solution with a chemical make-up similar to plasma except that there is no protein present.

altering the plasma chloride or bicarbonate concentrations. Slightly elevated plasma chloride levels may occur following the ingestion of fairly large quantities of salt and may sometimes be encountered in acidosis resulting from an excessive loss of bicarbonate (such as upper intestinal and pancreatic fistula, some cases of diarrhea and starvation). High electrolyte values are not often encountered clinically but when they do occur, or if they persist, it is almost always a result of inadequate kidney function. Increases in the electrolyte concentration most frequently occur in dehydration and, of course, result be cause of a greater deficiency of water than salts⁴⁷.

Normal or low plasma chloride or sodium concentrations are frequently encountered when dehydration is present^{10, 14} but such values may be obtained

also when studying overhydrated convalescent burned patients,^{15, 31} or individuals with malnutrition edema. Therefore, such determinations should not be regarded as necessarily indicating the need of salt and water. For example, in Table III are presented the findings in a patient with postoperative malnutrition edema. At first this patient was given a physiologic solution of sodium chloride in an attempt to restore the plasma chloride concentration to normal, but when the patient's edema became severe and the chloride level showed little change, this therapy was discontinued. It was then obvious that the patient's extracellular fluid volume had increased greatly and the chloride concentration did not mirror the state of hydration. If one assumed that such an individual had a normal extracellular fluid volume of 15,000 c c with a chloride concentration of 106 meq per liter, one could estimate that he should have approximately 1,590 meq of chloride in the extracellular fluid compartment under normal circumstances. Since an increase above the normal of about 5,000 c c may be necessary in an adult before edema can be noticed clinically⁵⁴ and since the edema in this patient was quite marked, it was assumed that the extracellular fluid volume would equal somewhere in the vicinity of 22,000 c c. By multiplying the determined chloride concentration (88 meq per liter) by the aforementioned figure it can be seen that approximately 1,836 meq of chloride were present. Thus, in this patient there apparently was an excess of chloride but because of a greater increase in water than in chloride the low level was obtained.

This man was effectively treated by stopping the salt intake completely for four days and then permitting only small amounts of it. Since there had been a reduced caloric and protein intake because of anorexia, vomiting, and diarrhea, he was not given anything by mouth but received intravenously 75

TABLE III POSTOPERATIVE MALNUTRITION EDEMA IN A 60 YEAR OLD MAN

DATE (1941)	TOTAL DAILY FLUID INTAKE (C C)	INTAKE OF SALT (GM PER DAY)	URINARY OUTPUT (IN C C)	HEMATO CRIT	PLASMA PROTEINS (GM PER 100 C C)	PLASMA CHLORIDES (MEQ PER LITER)	APPROXI MATE TOTAL EXTRA CELLULAR CHLORIDE (MEQ)	REMARKS
4/16	3,000	18	820	43.0	6.95	104.0		Operation
4/28	3,880	18	700	34.0	6.30	96.0		Wound dis ruption
5/16	3,200	18	620	31.0	4.92	85.0		Edema
5/19	3,000	27	475	30.6	4.82	88.0	1936.0	Edema in creased
5/20	3,600	0	1,270			94.0		
5/21	3,600	0	1,600	30.0	4.60	98.0		
5/22	3,600	0	2,150					
5/23	3,600	0	2,350					Edema free
5/24	2,700	6.3	1,750					
5/25	3,200	6.3	1,810	32.0	5.01	106.0	1590.0	
5/26	3,200	6.3	1,680					
5/30	-	-	1,240	35.0	5.64	104.0		Eating well
6/10	-	-	970	40.0	6.54			

to 90 Gm of protein in the form of amino acids* and 210 to 250 Gm of dextrose daily. The entire caloric intake, while not large, ranged between 1,200 to 1,300 calories per day. The patient was given parenteral feeding for ten days and during this time was in a positive nitrogen balance. The amount of urine excreted daily increased and the patient was visibly free from edema in seventy-two hours. The removal of the excess body water was thought to result from the high fluid and restricted salt intake, and the diuretic effect of urea (the latter being obtained from the intravenously administered casein hydrolysate). Parenteral therapy was discontinued and an adequate diet was then taken by mouth.

Plasma volumes and protein concentrations were obtained before and shortly after the ten days of parenteral feeding, and the results are shown in Table IV. By comparing the plasma protein concentration before and after therapy it would seem as though the plasma proteins were not increased, but by calculating the total circulating plasma protein level it can be seen that an increase of 27 per cent occurred.

TABLE IV CHANGE IN TOTAL CIRCULATING PLASMA PROTEINS FOLLOWING PARENTERAL AMINO ACID THERAPY

DATE	PLASMA VOLUME (IN C C)	PLASMA PROTEIN CONCENTRATION (GM PER 100 C C)	TOTAL CIRCULATING PLASMA PROTEIN (GM)	PER CENT CHANGE IN TOTAL CIRCULATING PLASMA PROTEIN
5/17/41	2,300	5.06	117.8	
5/29/41	2,930	5.10	149.5	+27

In this case, and in other patients with malnutrition edema, as well as in convalescent burned patients¹⁵ and animals,²² it has been noted that edema will often disappear when the protein concentration remains low. Similar observations have been made by Schemm⁵⁰ on cardiac and nephrotic patients. Because of these findings and because edema may occur in patients with a relatively normal plasma protein concentration⁴³ and may not occur when the plasma protein concentration is below 5 Gm per 100 cc, it is therefore obvious that the amount of water and salt consumed is extremely important and plays a significant part in the formation of edema. In many such cases the plasma protein and albumin concentrations often increase gradually following a diuresis. This rise appears to be a result of the body getting rid of fluid rather than a cause of it.

In Table V is shown the course of another patient with a marked malnutrition edema. Because of edema of the gastrointestinal tract the patient was vomiting frequently and having ten to sixteen watery stools a day. An effective diuresis was obtained by the administration of citrated blood, plasma, and suitable diuretics (ammonium chloride and mercupurin), and by the restriction of salt. This led to relief of gastrointestinal symptoms. It can be seen from these results that the plasma protein concentration was not significantly altered before or during the diuresis.

*Supplied by Frederick Stearns & Company, Detroit, Mich.

TABLE V RESPONSE OF A 28 YEAR OLD WOMAN PATIENT WITH POSTOPERATIVE MALNUTRITION EDEMA TO BLOOD AND PLASMA INTRAVENOUSLY AND DIURETICS

DATE	ORAL INTAKE (IN CC)	BLOOD	PLASMA (CC.)	URINE OUT PUT (IN CC)	HEMATO CRIT	PLASMA PROTEIN
3/4	475	1,000	300	6,200	36 0	3 54
3/5	675	(9 Gm of ammonium chloride given		1,500	35 7	3 87
3/6	500	daily for 3 days)		2,400		
3/7	450	(2 cc mercupurin)	425	1,200		
3/8	560			12,500	40 37	4 25-4 99
3/9	1,050			1,100	39 1	4 69
3/10	1,400			800		
3/11	1,135			1,500		
3/12	1,125	500	225	1,200	42 4	4.83
3/13	1,400			1,200		
3/14	1,745			1,900		
3/15	1,800	600		2,050		
3/16	1,620			2,000		
3/17	2,550	(2 cc mercupurin)		4,250		
3/18	2,175			1,400	45 0	5 34
3/19	1,750			1,300		
3/21	2,300			1,600		5 80
3/23					49 3	6 05
Total	22,710	2,100	950	44,100		

It has been stated⁴⁷ that death will rarely result from circulatory or renal insufficiency in cases of low intestinal obstruction because of alterations in body fluids. It has been accepted, however, that in pyloric or high intestinal obstruction a fatal outcome may frequently result from dehydration or an acid-base imbalance^{54, 57, 58, 59}. In low obstructions it was assumed that the body fluid compartments were not greatly altered because various blood constituents (hematocrit, protein, chloride) were normal. As shown in Table VI, such determinations may often be within a normal range even though there is a fairly marked deficit in the plasma volume and in the extracellular fluid compartment (roughly equal to the sodium thiocyanate space).

Gendel and Fine⁶⁰ have shown that distention resulting from intestinal obstruction or strangulation causes a rapid diminution in the plasma volume. While distention undoubtedly greatly accelerates the loss of body water, serious consequences may result from dehydration when distention is slight or absent. Toxic products or peritonitis may cause death in closed loop obstructions⁶¹ or when strangulation is present⁶² but evidence has been obtained which seems to indicate that death due to a simple mechanical obstruction may in some instances result solely from alterations in body water and salts.¹⁴

The fact that patients with severe diarrhea often develop a clinical picture resembling that seen in some cases of simple intestinal obstruction lends support to this concept. In regard to the importance of the fluid and electrolyte loss in diarrhea it has been stated by Marriott, Hartmann, and Senn⁶³ that "it has also become apparent that the severe toxic symptoms, the so called 'alimentary intoxication' are the secondary results of disturbances in the chemical equilibrium of the body brought about as the result of loss of water, salts and organic material by way of the gastrointestinal tract, and that the development

TABLE VI BLOOD STUDIES ON DOGS WITH SIMPLE MECHANICAL INTESTINAL OBSTRUCTION

DOG NO	LEVEL OF OBSTRUCTION	DURATION OF OBSTRUCTION	PER CENT CELL VOLUME HEMATOCRIT	PLASMA CHLORIDE (MEQ PER L)	PLASMA PROTEIN (GM PER 100 CC)	PLASMA VOLUME (CC)	PER CENT CHANGE IN PLASMA VOLUME
C 5	Pylorus	0	47.5	111.2	6.63	935	
		2	51.8	97.2	7.97	745	-25
C 6	Pylorus	0	42.4		6.86	1,148	
		1	45.3		8.02	866	-25
		3	45.3	73.6	9.23	760	-34
360	Pylorus	0	49.4	112.0	6.80	637	
		1	65.0	102.3	9.36	498	-22
316	Jejunum	0	43.5	110.0	5.94	565	
		2	57.0	80.1	8.40	431	-24
42.9	Jejunum	0	46.0	108.4	5.95	835	
		3	63.0	107.1	8.71	578	-31
319	Ileum	0	37.6	110.8	5.62	655	
		4	35.2	106.6	5.69	495	-25
338	Ileum	0	46.2	112.6	5.83	850	
		2	47.6	107.6	6.09	670	-21
		4	46.1	111.7	6.02	648	-24
345	Colon	0	51.6	103.6	6.76	812	
		8	54.2	87.5	6.53	640	-21
		13	52.5	80.9	8.04	445	-45
42.7	Colon	0	47.6	105.2	6.58	600	
		10	53.8	86.8	6.03	558	-7
		14	55.2	77.5	5.37	392	-35

of the clinical picture of intoxication depends more upon the degree and severity of the diarrhea than upon the nature of the underlying cause."

In patients with intestinal obstruction, a reduction in body fluids and in the plasma volume may occur in one or more of the following ways: (1) reduced intake, (2) excessive loss (vomiting, perspiration), (3) distention, (4) strangulation (with hemorrhage or transudation of fluid), or (5) infection (exudation of fluid).

On admission to the hospital, patients who have had obstruction for a few days or longer often have an elevated blood urea. This is well recognized and is a result of inadequate fluid being available for the excretion of the nitrogenous waste products (prerenal azotemia). Not infrequently such patients will show a trace of albumin and a few blood cells in the urine pre- and post-operatively, and even though the kidneys excrete 600 to 1,500 cc of urine a day, the blood urea remains elevated or, after a return toward normal, will subsequently rise. The elevated blood urea concentration occurs in such illnesses and in other seriously ill patients because of the existing kidney damage (the urinary specific gravity is usually low [1.002 to 1.012] demonstrating that the power of adequately concentrating urine has been lost), and because of an accelerated catabolism of the body proteins. Haden and Orr¹⁸ pointed out that some patients may excrete from 10 to 33 Gm of nitrogen per twenty-four hours following operation. Therefore, as these workers¹⁸ and others¹⁹ have shown, there is usually an increased amount of nitrogen to be eliminated. In dehydrated patients the importance of an excessive catabolism of body proteins, poor kidney function, and the lack of an adequate quantity of water to eliminate the nitrogenous waste products has been well stressed.¹⁷

TABLE VII PRERENAL AZOTEMIA IN A CASE OF INTESTINAL OBSTRUCTION (ILEUM)
(B E., 45 YEARS OF AGE)

DATE	HEMOGLOBIN (GM PER 100 C C)	PLASMA CHLORIDE (MG PER 100 C C)	BLOOD UREA (MG PER 100 C C)
3/27	15		
3/28	15	460	154
3/29	15		140
3/31	15	471	54
4/3		448	
4/4			251
4/6	12.5	461	116
4/9		454	64
4/11	12.0	482	28

In Tables VII and VIII are shown the alterations in the blood chemistry which occurred in two cases with a simple obstruction of the terminal ileum due to adhesions. The first patient, a 45-year-old man (Table VII), was admitted to the hospital with a five day history of intestinal obstruction. He was treated conservatively for twenty-four hours by intestinal intubation, but because he did not respond well, operation was decided upon (March 28, 1945). The patient improved for the first three days postoperatively and the blood urea was decreasing toward normal. The urinary output ranged between 800 to 1,500 c c and contained small amounts of albumin and cells. He developed pneumonia on the fourth postoperative day and penicillin (20,000 units every two hours) was begun. The pulmonary complications improved, but on the seventh postoperative day the blood urea concentration had risen to 251 mg per 100 c c. At this time the patient was mentally confused and showed a uremic frost. He was given 4,000 to 5,000 c c of 5 per cent dextrose in distilled water daily with a resulting increase in the urine volume and within one week's time there was a return of the blood urea concentration to normal. Similar findings occurred in the second patient, who was a 48-year-old woman with a four-day history of obstruction. She was operated upon March 4, 1945, and six days later the blood urea was near normal. During this period she had received adequate intravenous therapy and had excreted an adequate amount of urine. Subsequently she was given a diet by mouth, but because it was taken poorly the food and fluid intake decreased. The urinary output

TABLE VIII PRERENAL AZOTEMIA IN A CASE OF INTESTINAL OBSTRUCTION (ILEUM)
(E R., 48 YEARS OF AGE)

DATE	HEMOGLOBIN (GM PER 100 C C)	PLASMA CHLORIDE (MG PER 100 C C)	BLOOD UREA (MG PER 100 C C)
3/4	13.5		
3/10	11.5		
3/12	9.0		45
3/16			128
3/19	9.5	421	156
3/23			148
3/31	9.0	531	46
4/4	9.25		35

which had been higher, then decreased to between 800 and 1,300 c c per day, but in spite of what appeared to be a fairly adequate output, the blood urea rose. The specific gravity of the urine ranged between 1.004 and 1.013 and because of her clinical condition it was felt that in all probability she was in a period of excessive nitrogen destruction (because of an inadequate caloric intake, pulmonary complications, dehydration, and the dehiscence of the abdominal wound). When adequate fluid was provided and the urine volume increased to around 2,000 c c per day, the blood urea returned to normal.

Similar findings were observed in another case. The chemical alterations noted are shown in Table IX. This 66-year-old man was admitted to the hospital with pyloric obstruction. There had been vomiting for several days and he had taken very little fluid. The blood urea was only slightly elevated on admission and although gastric suction was begun he was permitted small amounts of fluid by mouth and given an additional 2,500 c c of fluid daily by vein. Because of the prolonged obstruction with dehydration and a posterior duodenal ulcer which had perforated through into the common bile duct, the patient was apparently in a marked nitrogen catabolic phase. On May 5, at surgical consultation, it was felt that the uremia was due to an accelerated catabolism, inadequate caloric intake, and dehydration. The fluid and caloric intake was increased and the patient showed a rapid improvement. Eventually the inflammatory reaction subsided and the patient was then able to get along well on an oral intake alone.

TABLE IX PRERENAL AZOTEMIA IN A PATIENT WITH PYLORIC OBSTRUCTION
(C A., 66 YEARS OF AGE)

DATE	HEMOGLOBIN (GM PER 100 C C)	BLOOD UREA (MG PER 100 C C)	TOTAL DAILY FLUID (INTAKE IN C C)	DAILY OUTPUT OF URINE (C C)
4/30		45		
5/3	12.0	240	2,470	480
5/4		260	2,750	260
5/5	13.5	300	4,260	520
5/7		268	4,440	1,550
5/8		242	4,710	1,010
5/9	11.0	203	5,600	2,300
5/12		111	4,900	2,310
5/15	9.0	36	3,700	3,650
5/17		28	3,500	2,420

While the cause of uremia seems quite obvious, it was surprising to find that some of the physicians who observed these cases felt that the urine output was adequate and that the kidneys had failed.

Since such patients often cannot excrete excesses of salt well, and the protein reserves are depleted, it is essential that they be given 4,000 to 5,000 c c of 5 to 10 per cent glucose in distilled water if the urine volume is to be raised sufficiently to clear the nitrogenous breakdown products. A similar phenomenon may occur during convalescence from a burn.¹⁵ Here again there is a period of accelerated catabolism when the kidneys are not able to work at the highest degree of efficiency.

TABLE VII PRERENAL AZOTEMIA IN A CASE OF INTESTINAL OBSTRUCTION (ILEUM)
(B. E., 45 YEARS OF AGE)

DATE	HEMOGLOBIN (GM PER 100 C C)	PLASMA CHLORIDE (MG PER 100 C C)	BLOOD UREA (MG PER 100 C C)
3/27	15		
3/28	15	460	154
3/29	15		140
3/31	15	471	54
4/3		448	
4/4			251
4/6	12.5	461	116
4/9		454	64
4/11	12.0	482	28

In Tables VII and VIII are shown the alterations in the blood chemistry which occurred in two cases with a simple obstruction of the terminal ileum due to adhesions. The first patient, a 45-year-old man (Table VII), was admitted to the hospital with a five-day history of intestinal obstruction. He was treated conservatively for twenty-four hours by intestinal intubation, but because he did not respond well, operation was decided upon (March 28, 1945). The patient improved for the first three days postoperatively and the blood urea was decreasing toward normal. The urinary output ranged between 800 to 1,500 c c and contained small amounts of albumin and cells. He developed pneumonia on the fourth postoperative day and penicillin (20,000 units every two hours) was begun. The pulmonary complications improved, but on the seventh postoperative day the blood urea concentration had risen to 251 mg per 100 c c. At this time the patient was mentally confused and showed a uremic frost. He was given 4,000 to 5,000 c c of 5 per cent dextrose in distilled water daily with a resulting increase in the urine volume and within one week's time there was a return of the blood urea concentration to normal. Similar findings occurred in the second patient, who was a 48-year-old woman with a four-day history of obstruction. She was operated upon March 4, 1945, and six days later the blood urea was near normal. During this period she had received adequate intravenous therapy and had excreted an adequate amount of urine. Subsequently she was given a diet by mouth, but because it was taken poorly the food and fluid intake decreased. The urinary output

TABLE VIII PRERENAL AZOTEMIA IN A CASE OF INTESTINAL OBSTRUCTION (ILEUM)
(E. R., 48 YEARS OF AGE)

DATE	HEMOGLOBIN (GM PER 100 C C)	PLASMA CHLORIDE (MG PER 100 C C)	BLOOD UREA (MG PER 100 C C)
3/4	13.5		
3/10	11.5		45
3/12	9.0		
3/16			128
3/19	9.5	421	156
3/23			148
3/31	9.0	531	46
4/4	9.25		35

REFERENCES

- 1 Drew, C R, Scudder, J, and Papps, J Controlled Fluid Therapy With Hematocrit, Specific Gravity and Plasma Protein Determinations, *Surg, Gynec & Obst* 70 859 867, 1940
- 2 Wolff, W A, and Lee, W E A Simple Method for Estimating Plasma Protein Deficit After Severe Burns, *Ann Surg* 115 1125 1130, 1942
- 3 Gray, P A, and Elliot, A. H. The Specific Gravity of Whole Blood and Serum, *Am. J M Sc* 205 356 363, 1943
- 4 National Research Council Burns, Shock, Wound Healing and Vascular Injuries, Military Surgical Manual, Philadelphia, 1943, W B Saunders Company
- 5 Jenkins, H P, Schafer, P W, and Owens, F M, Jr Guide to Replacement Therapy for Loss of Blood or Plasma, *Arch Surg* 47 1 3, 1943
- 6 Lam, C R The General Care of the Burned Patient, *J A. M. A* 125 543 546, 1944
- 7 Seamen, B W, and Ponder, E The Estimation and Control of Post operative Dehydration With the Aid of Hemoglobin and Plasma Protein Determinations, *J Clin. Investigation* 22 673 685, 1943
- 8 Zintel, H A The Role of Nutrition in Preoperative and Postoperative Care A Review, *Am. J M. Sc* 207 253 258, 1944.
- 9 Fox, P F Administration of Intravenous Fluids to Surgical Patients, *Am J Surg* 67 8 15, 1945
- 10 Hoffman, W S, and Osgood, B The Value of Blood Chloride and Sodium Determinations in the Diagnosis of Dehydration, *J Lab & Clin Med* 27 1174-1182, 1942
- 11 Carr, J L Laboratory Routine for Fluid, Electrolyte and Protein Control in Surgical Patients, *Surg, Gynec & Obst* 79 438 440, 1944
- 12 Harkins, H N, Cope, O, Evans, E I, Phillips, R A., and Richards, D W, Jr The Fluid and Nutritional Therapy of Burns, *J A M A* 128 475-479, 1945
- 13 Griffin, G E, Abbott, W E, Pride, M P, Muntwyler, E, Mautz, F R, and Griffith, L Plasma Volume "Available (Thiocyanate) Volume" and Total Circulating Plasma Proteins in Normal Adults, *Ann Surg* 121 352 360, 1945
- 14 Abbott, W E, Mellors, R C, and Muntwyler, E Fluid, Protein and Electrolyte Alterations in Experimental Intestinal Obstruction, *Ann Surg* 117 39 51, 1943
- 15 Abbott, W E, Pilling, M A., Griffin, G E, Hirshfeld, J W, and Meyer, F L Metabolic Alterations Following Thermal Burns V The Use of Whole Blood and an Electrolyte Solution in the Treatment of Burned Patients, *Ann Surg* 122 678 692, 1945
- 16 Abbott, W E, and Mellors, R C Total Circulating Plasma Proteins in Surgical Patients With Dehydration and Malnutrition. Indications for Intravenous Alimentation With Amino Acids, *Arch Surg* 46 277 288, 1943
- 17 Marriott, W McK. Anhydremia, *Physiol Rev* 3 275 294, 1923
- 18 Lyons, C Penicillin Therapy for Surgical Infections in the U S Army, *J A M A* 123 1007 1018, 1943
- 19 Metcalf, J, Favour, C B, and Stare, F J Plasma Protein and Hemoglobin in the Protein Deficient Rat A Three Dimensional Study, *J Clin. Investigation* 24 82 91, 1945
- 20 Lyons, R H, Jacobson, S D, and Nurkin, J L The Relationship Between Changes in Serum Protein Concentration and the Plasma Volume in Normal Subjects, *J Lab & Clin Med* 30 404-411, 1945
- 21 Gibson, J G, Jr, and Evans, W A., Jr Clinical Studies of the Blood Volume II The Relation of Plasma and Total Blood Volume to Venous Pressure, Blood Velocity Rate, Physical Measurements, Age and Sex in Ninety Normal Humans, *J Clin Investigation* 16 317 328, 1937
- 22 Abbott, W E, Hirshfeld, J W, and Meyer, F L Metabolic Alterations Following Thermal Burns II Changes in the Plasma Volume and Plasma Protein in the Convalescent Phase, *Surg, Gynec & Obst* 81 25 30, 1945
- 23 Buckley, G E, Abels, J C, and Rhoads, C P The Treatment of Postoperative Hypoproteinemia in Patients With Cancer of the Colon and Rectum, *Ann Surg* 117 748 753, 1943
- 24 Thornton, T F Jr, Adams, W E, and Schafer, P W Hypoproteinemia in Thoracic Surgery A Clinical Study, *Surg, Gynec & Obst.* 79 368 373, 1944
- 25 Lyons, R H, Jacobson, S D, and Avery, N L Increases in the Plasma Volume Following the Administration of Sodium Salts, *Am J M Sc.* 208 148 151, 1944
- 26 Warren, J V, and Stead, E A Fluid Dynamics in Chronic Congestive Heart Failure An Interpretation of the Mechanism Producing the Edema Increased Plasma Volume and Elevated Venous Pressure in Certain Patients With Prolonged Congestive Failure, *Arch Int Med* 73 138 147, 1944
- 27 Rees, V L, and Iob, V L The Effects of Ether Anesthesia on Renal Function *Univ Hosp Bull, Ann Arbor* 9 70 71, 1943

- 28 Lauson, H D, Bradley, S E, and Cournaud, A The Renal Circulation in Shock, *J Clin Investigation* 23 381 402, 1944
- 29 Adolph, E F Oxygentension and Urine Production in Frogs, *Am J Physiol* 111 75 82, 1935
- 30 Browne, J S L, Karady, S, and Selye, H The Effect of Noxious Agents on Creatine, Creatinine, Chloride and Water Excretion, *J Physiol* 97 17, 1939
- 31 McIver, M A Study in Extensive Cutaneous Burns, *Ann Surg* 97 670 682, 1933
- 32 Nicholson W M, and Taylor, H M The Effect of Alcohol on the Water and Electrolyte Balance in Man, *J Clin Investigation* 17 279 285, 1938
- 33 Lussky, H O, and Friedstein, H Water Retention in Pneumonia, *Am J Dis Child* 19 337 343, 1920
- 34 Wilder, T S, and Drake, T G H Metabolism of Chloride and Total Fixed Base in Pneumonia and the Relation to Salt and Water Retention, *J Clin Investigation* 7 353 364, 1929
- 35 Rutstein, D D, Thomson, K J, Tolmach, D M, Walker, W H, and Floody, R J Plasma Volume and "Extravascular Thiocyanate Space" in Pneumococcus Pneumonia, *J Clin Investigation* 24 11 20, 1945
- 36 Fletcher, P H, and Schroeder, H A Studies on Congestive Heart Failure II Impaired Renal Excretion of Sodium Chloride, *Am J M Sc* 204 52 62, 1942
- 37 Loeb, R F The Adrenal Cortex and Electrolyte Behavior, Harvey Lecture, *Bull New York Acad Med* 18 263 288, 1942
- 38 Coller, F A, Campbell, K N, Vaughn H H, Iob, V, and Moyer, C A Postoperative Salt Intolerance, *Ann Surg* 119 533 542, 1944
- 39 Coller, F A, Iob, V, Vaughn, H H, Kalder, N B, and Moyer, C A Translocation of Fluid Produced by the Intravenous Administration of Isotonic Salt Solutions in Man Postoperatively, *Ann Surg* 122 663 677, 1945
- 40 Lambert, E M, Power, M H, Pemberton, John DeJ, and Wakefield, E G Effects of the Parenteral Administration of Fluids on the Metabolism of Electrolytes During Postoperative Convalescence, *Surg, Gynec & Obst* 80 609 614, 1945
- 41 Trout, H H Proctoclysis An Experimental Study, *Surg, Gynec & Obst* 16 560 562, 1913
- 42 Matas, R The Continued Intravenous Drip *Ann Surg* 79 643 661, 1924
- 43 Jones, C M, Eaton, F B, and White, J C Experimental Postoperative Edema, *Arch. Int Med* 53 649 674, 1934
- 44 Landis, E M Capillary Pressure and Capillary Permeability, *Physiol Rev* 14 404 481, 1934
- 45 Priestly, J G The Regulation of Excretion of Water by the Kidneys, *J Physiol* 50 304 311, 1916
- 46 Winkler, A W, Elkinton, J R, Hopper, J, Jr, and Hoff, H E Experimental Hyper-tonicity Alterations in the Distribution of Body Water, and the Cause of Death, *J Clin Investigation* 23 103 109, 1944
- 47 Darrow, D C Body Fluid Physiology The Relation of Tissue Composition to Problems of Water and Electrolyte Balance, *New England J Med* 233 91 97, 1945
- 48 Yannet, H, and Darrow, D C Effect of Depletion of Extracellular Electrolytes on Chemical Composition of Skeletal Muscle, Liver and Cardiac Muscle, *J Biol Chem* 134 721 737, 1940
- 49 Darrow, D C, and Yannet, H Changes in Distribution of Body Water Accompanying Increase and Decrease in Extracellular Electrolyte, *J Clin Investigation* 14 266-275, 1935
- 50 Hastings, A B, and Echelberger, L Exchange of Salt and Water Between Muscle and Blood Effect of Increase of Isotonic Salt Solutions, *J Biol Chem* 117 73 93, 1937
- 51 Mellors, R C, Muntwyler, E, and Mautz, F R Electrolyte and Water Exchange Between Skeletal Muscle and Plasma in the Dog Following Acute and Prolonged Extracellular Electrolyte Loss, *J Biol Chem* 144 773 784, 1942
- 52 Elman, R Parenteral Fluids and Food in Gastrointestinal Disease, *Bull New York Acad Med* 20 220 236, 1944
- 53 Ficarra, B J, and Nacelino, E A The Physicochemical Disturbance in a Severe Burn, *SURGERY* 16 529 541, 1944
- 54 McIver, M A, and Gamble, J L Body Fluid Changes Due to Upper Intestinal Obstruction, *J A M A* 91 1589 1592, 1928
- 55 Peters, J P Water Exchange, *Physiol Rev* 24 491 531, 1944
- 56 Schemm, F R A High Fluid Intake in the Management of Edema, Especially Cardiac Edema II Clinical Observations and Data, *Ann Int Med* 21 937 976, 1944
- 57 Elman, R, and Hartmann, A F Experimental Occlusion of the Terminal Ileum Importance of Blood Chemical Changes in Causing Death, *Surg, Gynec & Obst* 53 307 315, 1931

- 58 Haden, R L, and Orr, T G The Cause of Certain Acute Symptoms Following Gastroenterostomy, Bull Johns Hopkins Hosp 34 26 30, 1923
- 59 Haden, R L, and Orr, T G The Effect of Sodium Chloride on the Chemical Changes in the Blood of the Dog after Pyloric and Intestinal Obstruction, J Exper Med 38 55 71, 1923
- 60 Gendel, S, and Fine, J The Effect of Acute Intestinal Obstruction on the Blood and Plasma Volumes, Ann Surg 110 25 36, 1939
- 61 Harper, W H, and Blain, A, III The Effect of Penicillin in Experimental Intestinal Obstruction Preliminary Report on Closed Loops Studies, Bull Johns Hopkins Hosp 76 221 244, 1945
- 62 Sarnoff, S J, and Fine, J The Effect of Chemotherapy on the Ileum Subjected to Vascular Injury, Ann Surg 121 74 82, 1945
- 63 Marriott, W McK, Hartmann, A F, and Senn, M J E Observations on the Nature and Treatment of Diarrhea and the Associated Systemic Disturbances, J Pediat. 3 181 191, 1933
- 64 Gomori, P, Podhradsky, L Protein Disintegration in Hypochloremic Azotemia After Pylorus Obstruction and Its Mechanism, Acta med Scandinav 92 515 524, 1937
- 65 Gomori, P, and Podhradsky, L The Mechanism of Extrarenal (Hypochloremic) Azotemia, Acta Med Scandinav 92 347 356, 1937
- 66 Moyer, C A, Collier, F A, Iob, V, Vaughan, H H, and Marty, D A Study of the Interrelationship of Salt Solutions, Serum and Defibrinated Blood in the Treatment of Severely Scalded, Anesthetized Dogs, Ann Surg 120 367 376, 1944
- 67 Fox, C L Oral Sodium Lactate in the Treatment of Burn Shock, J A M A 124 207 212, 1944
- 68 Butler, A M, and Talbot, N B Parenteral Fluid Therapy I Estimation and Provision of Daily Maintenance Requirements, New England J Med 231 585 590, 1944

ARTERIAL INJURIES OF WARFARE

COMPLICATIONS AND MANAGEMENT

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A CONSIDERABLE number of interesting lesions of the larger arteries and veins have been seen among the casualties of World War II because of frequent injury by fragments of small size. Multiple high-speed fragments produce small perforating wounds, which have many times not been fatal and which have been associated with partial or incomplete laceration of blood vessels, giving rise to recurrent hemorrhage, false aneurysm, and arteriovenous fistula and aneurysm. A fragment, $\frac{1}{2}$ cm in size, can produce a small perforation in the wall of an artery or pass between an adjacent artery and vein, producing injury to the wall of each without destroying the continuity of the vessels and without producing massive hemorrhage. An increasing experience with this type of vascular injury and with its complications has developed certain principles and made clear the advantages of certain methods of management, which have greatly advanced our understanding of the problems associated with these injuries.

The patients in the series of twenty-six lesions in twenty-five cases described here were seen during the South and Central Pacific campaigns, at periods following injury, varying from a few hours to the time of arrival at a base hospital after several days or weeks. They present a wide variety as to the nature of the injury, the course of the lesion, and the type of complication as well as the management and operative treatment.

The common characteristic factor in this type of injury is *incomplete* arterial laceration, for it is partial section of the arterial wall which gives continued and recurrent bleeding with its resultant complications. Complete section of a larger artery, when not ligated, if not immediately fatal, is followed by retraction of the stump and natural occlusion of the lumen by clot, in the presence of a much lowered arterial tension, very possibly aided by the intimal plug produced by the retraction of the elastic wall. If the hemorrhage stops under such circumstances, further complications are rarely seen. The opportunity to observe such a situation was presented in a noncombat injury, in which fracture of the lower third of the femur was followed by immediate ischemia and absence of pulsations in the lower leg and foot but with no hematoma or swelling of the thigh. He was admitted to the base hospital two days after injury with an early demarcating gangrene just below the knee and a small puncture wound compounded from within on the lateral surface of the lower thigh, which had been primarily cleaned and dressed, and appeared clean. It was felt that there was a complete section of the lower portion of the femoral artery. While awaiting the final demarcation of a dry gangrene at the knee, prophylactic tetanus and gas antitoxin had been given, and without warning, sudden appearance of a virulent gas bacillus infection through the leg and thigh made necessary

emergency operation, which was a guillotine amputation through the fracture site and drainage of the muscle groups of the thigh. It was possible at that time to observe directly nature's response to the arterial injury. There had been complete section of both artery and vein by the sharp edge of the femoral fragment and these two vessels lying together in the end of the stump were found to be filled with a firm clot for a distance of 6 to 8 cm from the cut end. The artery was found to be somewhat dilated and a faint pulsation was transmitted through the clot to the cut end of the artery, from which, however, there was no evidence of hemorrhage. There was a moderate amount of fibrinous exudate around these vessels, but there was no evidence of any hematoma in the tissues around the fracture site.

However, with partial section of the wall of the artery, or a small perforation, the retractile force of the elastic wall serves only further to enlarge the size of the opening and reduce the possibility of spontaneous cessation of the hemorrhage. This is indicated in Fig 1, which shows diagrammatically the incomplete arterial laceration and the mechanism of development of the several complications which commonly follow. In Table I and Fig 2 are indicated the anatomic location and the distribution on the arterial tree of the lesions in this series.

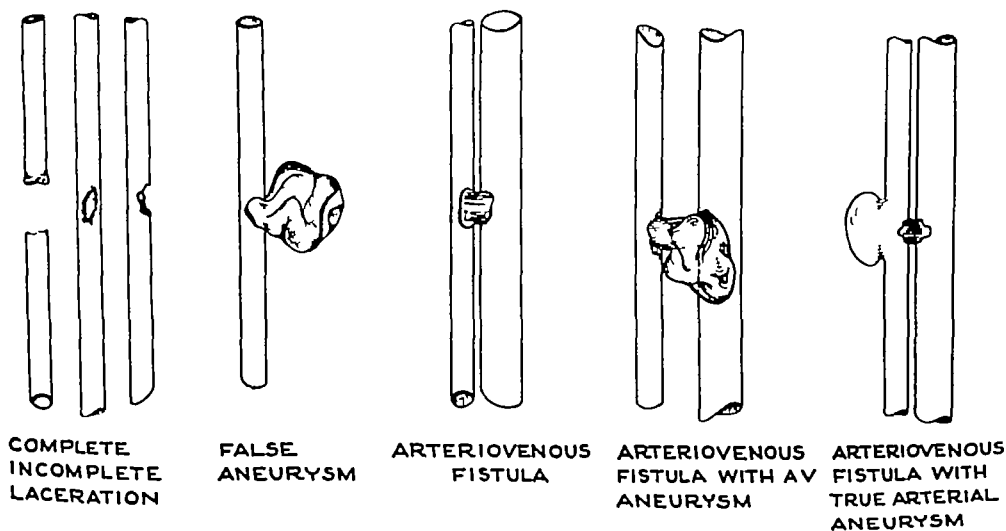


Fig 1—Types of lesions complicating incomplete arterial laceration

With partial arterial laceration, under varying circumstances, the pathologic process may follow any one of a number of courses that lead to the complications demonstrated in this group of cases. Obviously, there may be spontaneous arrest of the hemorrhage or continued bleeding to the exterior through the wound. Of extreme importance, and not always recognized, is the group in which there is the formation of a hematoma in a partially opened wound with repeated recurrence of delayed hemorrhage from the deep artery with a small perforation or partial laceration which has not been effectively dealt with. When the arterial injury is deep under fascial planes or muscles where there is no ready

TABLE I INCOMPLETE ARTERIAL LACERATION, LOCATION OF LESIONS

ARTERY	ARTERIOVENOUS FISTULA	PULSATING HEMATOMA FALSE ANEURYSM	RECURRENT HEMORRHAGE	LACERATION AND LIGATION
Ulnar		xx		
Radial		\		
Brachial	x	xx		
Axillary		xx		
Subclavian		xx		
Lateral thoracic			x	
Carotid	xx			
Supraorbital	x			
Femoral	xx			\
Popliteal	x	\		
Posterior tibial		\	xx	
Anterior tibial		\	\	
Total	7	13	5	1

exit to the exterior, a hematoma frequently develops, its size being dependent upon the resistance offered to the escaping blood by the surrounding tissues and upon how quickly tissues build up a pressure equal to the intra-arterial tension to stop the bleeding. A small hematoma such as this may be absorbed. A larger one, where there is a center of fluid blood pulsing constantly from the artery, will lead to the formation of a definite fibrous wall to produce the so called false aneurysmal sac through peripheral clot organization and fibroblastic proliferation. From this stage there may be partial regression and gradual diminution in the size of the sac, or repeated hemorrhage with enlargement, either gradual or sudden, to a point where through pressure on the artery itself or on the collateral channels by the swelling, ischemia-serious impairment of the circulation of the extremity may be found. The presence of a concomitant laceration of an adjacent vein may lead to the development of a permanent arteriovenous communicating channel, with or without an associated aneurysmal sac, which in turn has a pronounced tendency toward contraction and may lead to partial or rarely complete healing of the lesion.

Among the factors which may affect the course of the clinical pathologic picture are the size of the injured artery, the size of the laceration in its wall, the size of the path of the missile which may serve as an exit for the blood, the nature of the surrounding tissues such as the tightness of the fascia or the proximity of loose areolar planes where the blood may dissect, the tightness of the compression applied with the first emergency dressing, roughness or gentleness in transportation, adequacy of splinting, and the presence of a concomitant laceration in an adjacent vein, whether the early level of arterial tension is low from shock or high from active intravenous therapy.

In the necessary haste of evacuating large numbers of casualties these lesions are frequently overlooked and it is important to stress the fact that the presence of small aneurysms is not always apparent upon a cursory examination. A through-and-through bullet wound usually heals promptly without infection and the deep aneurysm may present no external signs. In a number of the cases the aneurysms were discovered late, by careful examination, by the patient him-

self, or by the sudden appearance of deep or superficial hemorrhage. A stethoscope is often the only way to identify the presence of an aneurysm. With regard to the local signs and symptoms, several features may be noted. Of course the bruit and palpable thrill, which are systolic in time in false aneurysm and continuous throughout both systole and diastole without interruption in arteriovenous fistulas, present the diagnostic evidence for the presence of these lesions, and the presence of a palpable or visible pulsation, though commonly found, is *not* a constant or necessary diagnostic sign.

In two of the unrecognized cases, severe throbbing pain called attention to the local lesion.

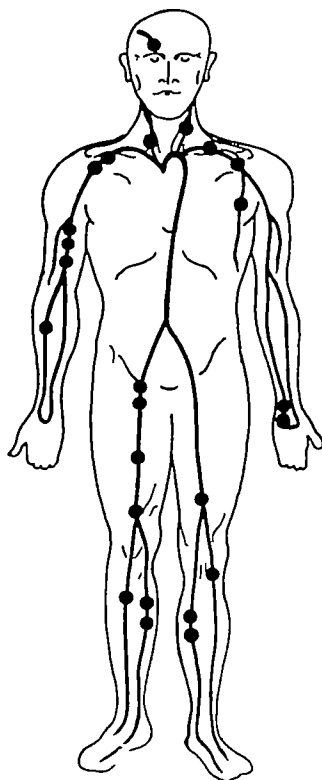


Fig. 2—Arterial injuries distribution

CASE 1—C. C. received a bullet wound of the lower part of the right upper arm in the supracondylar area which produced a compound, comminuted fracture of the lower end of the humerus, primary debridement was done and a cast applied four days later. Severe, steady, throbbing pain developed in the lower arm, which was not relieved by cutting of the cast. The hand became numb and the pain continued with extreme severity in the lower arm and above the elbow. Following his evacuation from the beach, he was seen at the base hospital seventeen days after the injury. When the cast was removed a 6 cm. pulsating mass was present in a large, granulating wound in the lower mesial surface of the upper arm. Operation was done at once and a false aneurysmal sac was identified, which, after the brachial artery was divided and ligated just above and below, was opened and evacuated. There was immediate relief of pain. No impairment of the circulation of the forearm and hand was noted. The humeral fragments were brought into line and a second cast was applied.

CASE 2—F S received a through and through bullet wound in the lower left thigh, which healed cleanly and without incident. He was evacuated with slight swelling above the knee and with minimal stiffness and admitted to the base hospital one month after injury. At that time, notes were made of the healed wounds and slight swelling about the knee, with limitation of motion but no effusion. He was sent to a convalescent ward and put on exercises and physical therapy. Three weeks later, there appeared sudden, severe pain and swelling above the left knee. Examination revealed grade III, tender, tense swelling both anteriorly and posteriorly, with a barely definable, deep pulsation in a small 2 cm area in the popliteal area, and a systolic bruit heard only in this area. There was no pulsation in the arteries of the foot, and increasing pain and swelling developed. Operation was performed because of threatened ischemia. A false aneurysmal sac of the popliteal artery, from which there had been a leak into the tissues, was found, evacuated, and the artery ligated and divided. This case was recognized because of sudden pain from the secondary hemorrhage. Operation was done at seven weeks, and popliteal ligation did not affect adversely the circulation of the distal lower leg. The course was smooth and the patient became ambulatory.

Another sign which is prominent is the sterile inflammatory reaction surrounding the hematoma. This is generally of marked degree and frequently produces induration and a hard, red, brawny swelling which may be quite extensive. It should be stressed that it is common to have no fluctuation, and frequently no pulsation, or one which because of the induration is not readily evident. These factors are likely to lead to uncertainty or a mistake in diagnosis. When, because of the inflammatory redness and induration, the surgeon is led to consider the lesion to be an abscess, his error may be embarrassing and costly. The valuable sign, of course, is the audible bruit, which should always be searched for. This is illustrated by Case 3.

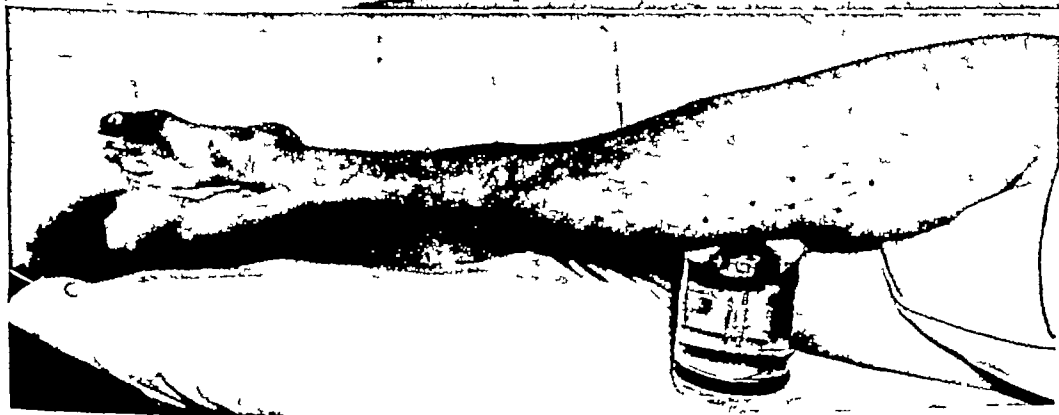
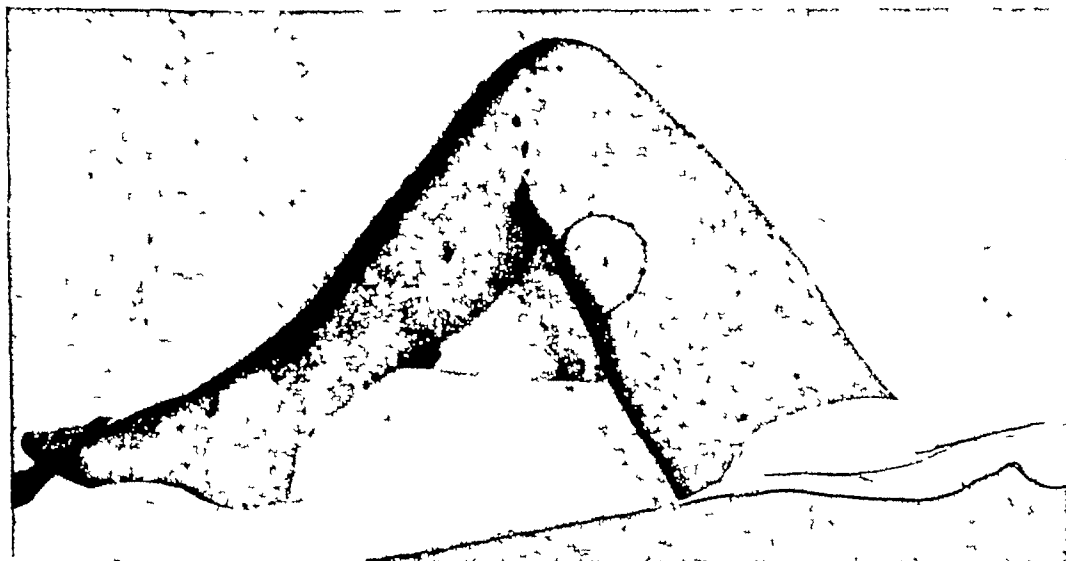
CASE 3—J P received a bullet wound of the right upper arm which healed under routine treatment and caused no trouble except for moderate throbbing pain, until he was admitted to the hospital eighteen days after injury. He had an injury to the hand, for which he was being treated on the orthopedic service, when suddenly, six weeks after injury, he developed an increase in the pain of the upper arm with a tense, tender, red, indurated, grade III swelling, extending both anteriorly and posteriorly almost the length of the humerus. This was so characteristic of an inflammatory reaction that incision and drainage was at first considered, when further examination showed a minimal pulsation and the pathognomonic systolic bruit audible over the mesial surface of the arm. Abscess could have been considered readily if an aneurysm had not been suspected and verified. Because of the imminence of circulatory insufficiency in the extremity, an immediate operation was done and after the axillary artery was isolated in the axilla and a tape placed about it to control the blood supply, dissection at the site of the lesion through densely infiltrated tissue with much local edema demonstrated the false arterial sac, which was opened, evacuated, and the artery divided and ligated. This was just below the profunda branch and there were no symptoms of circulatory insufficiency.

A prominent characteristic of both the false aneurysm and the arteriovenous fistula is the common tendency for spontaneous regression and contraction of the lesion under observation, which is striking in several of these cases. Therefore, postponement of the operative attack on these lesions during an adequate period of observation is indicated—because of this tendency, because of the greater ease of the surgical approach through tissues in which the induration and the acute inflammatory reaction have subsided, because of the decrease and disappearance of the infectious factor with the passage of time, and, finally, because of the obvious advantage of allowing for the maximum development of an

adequate collateral circulation During this period, exercises may be carried out to this end by systematic closure of the lesion by pressure for increasing periods of time, which provides the best stimulus to the development of collateral channels

CASE 4—F K was hit in the right thigh by a small mortar shell fragment which produced small wounds that healed promptly after emergency treatment Subsequently he noticed only soreness and aching in the thigh The lesion was not recognized until admission to the base hospital fourteen days following the injury, when the patient himself noticed the

A



B

Fig 3—Arteriovenous aneurysm femoral artery A Circle indicates pulsating mass below healed wound of entry Outer dotted line indicates area of transmitted continuous bruit and thrill B Mechanism of closure exercise

presence of a buzzing mass in the thigh with increasing discomfort and swelling of the leg and foot Careful examination at this time revealed, on the anteromesial aspect of the right mid thigh, a 7 cm diameter egg shaped pulsating mass visible and palpable, with a continuous palpable thrill and a continuous audible bruit over a large surrounding area which were eliminated by compression of the femoral artery This mass was held for two

months before operation while the arteriovenous fistula was closely observed. Closure exercises were carried out by the patient through this period in the manner shown in Fig 3 and the size of the lesion showed a marked decrease prior to the time of operation. Compression of the lesion was begun at fifteen minutes, three times a day, and gradually increased to one hour, four times a day. This was checked with a stethoscope and was effective in completely shutting off the flow of blood through the femoral artery. The weight of the man's leg was adequate to accomplish this. At first the closure produced marked cyanosis in the leg and foot and some discomfort, but this improved gradually day by day so that just prior to operation interruption of blood flow through the lesion produced practically no objective change in the color of the extremity and was accomplished with no discomfort to the patient. He was operated upon eleven weeks after injury under a tourniquet placed about the upper thigh. The sac was identified lying just medial to the femoral vessels, and division and ligation of the artery and the vein both proximally and distally were carried out with excision of the vascular segments, the fistulous tract, the aneurysmal sac, and a great many collateral veins which entered the lesion from below. This man had a smooth postoperative course and was evacuated to the United States, ambulatory and asymptomatic.

In a second arteriovenous fistula, to be described, between the carotid and the internal jugular, similar exercises produced a diminution in size of the pulsating mass and shortening of the limb during the preoperative period.

In most cases an optimum elective time may be selected for operative repair. However, occasionally emergency intervention may be indicated by recurrent hemorrhage, by sudden increase in the swelling and pain from active bleeding into an aneurysmal sac or the surrounding tissues (which may imperil, by pressure, the circulation in an extremity), or by the threat of, or actual, rupture.

RECURRENT HEMORRHAGE

Recurrent delayed hemorrhage is of particular importance. The occurrence of delayed secondary hemorrhage from the depth of a wound is enough evidence to warrant a formal operative procedure with wide exposure, demonstration of the injury to the vessel, and division and careful ligation. These cases in which there has been recurrent delayed hemorrhage, of which there are five, presented a total of sixteen episodes in which, prior to their final adequate treatment, hemorrhage from an incompletely severed artery had been ineffectively treated by dressings, pressure, packing, clamping in the depth of a wound and deeply placed sutures in the general location of the bleeding without adequate visualization and definition of the artery. Temporizing procedures in the presence of such hemorrhage are wholly unsatisfactory, never represent a solution to the surgical problem, and have led to situations of considerable danger to the patient. The artery must be divided and the ligated ends allowed to retract before the hemorrhage will stop. Several cases illustrate particularly this type of problem, such as Case 5.

CASE 5.—T. H. received a deep flesh wound in the left calf, he was brought on board ship after severe hemorrhage, and given the usual treatment. Nine days later he had sudden severe hemorrhage from the leg wound, controlled with a tourniquet, but no bleeding point was found and the wound was packed, which stopped the hemorrhage for the time being. The red count was down to 23 million and he was given plasma and transfusions. Four days later there was a second severe hemorrhage, when he was taken to the operating room and the bleeding point found, but when the vessel could not be isolated, a deeply placed

suture was found apparently to control the bleeding. He was given another transfusion of 1,000 cc. At another hospital on four other occasions there were minor hemorrhages from the wound, which were controlled by packing. He came under observation at the base hospital seventeen days after injury, when a large, ragged soft tissue wound involving two thirds of the calf was found. There was a minimal, slow oozing from the wound. Four days after admission and twenty one days after injury, a sudden massive hemorrhage developed and when, this time, he was taken to the operating room, the leg was widely opened and the posterior tibial artery isolated, divided, and ligated. Following this, the course was smooth.

CASE 6—S K had a deep flesh wound in the right calf and before admission to the base hospital had four episodes of hemorrhage from the leg treated by dressings and packing. He was admitted twenty days after injury, and on the day after admission, during dressing, there was a sudden hemorrhage from the wound. He was taken to the operating room and the artery and vein were ligated in continuity. Six days later a sudden further hemorrhage occurred and at reoperation this time the posterior tibial artery was located, divided, and ligated. Following this, the course was smooth.

CASE 7—S V was admitted fourteen days after injury, with small healing wounds in the lower posterior left axilla and in the pectoral fold anteriorly. He had partial loss of median and ulnar nerve function, and presented considerable induration of the axilla both anteriorly and posteriorly. On admission, a spurting hemorrhage was noticed from the posterior wound, which was a very small puncture wound. Pressure controlled this, but on three subsequent occasions this recurred in small degree and was handled promptly by pressure. The operation was postponed in the case because of the complication of threatening infection in this area and the extent of the procedure which would have been necessary to expose the entire axilla in searching for the unknown source of the bleeding. It did not seem as though the axillary artery were involved. Finally, however, seventeen days after admission, the swelling became much more extensive, with induration and pain in the entire axilla and edema of the arm, and at operation, in which wide exposure of the axilla was done, exploration revealed a large hematoma in the lower axilla into which there was active bleeding from the lateral thoracic artery, which had a tangential laceration. This was divided and ligated with silk. There was no injury to the axillary artery but the picture at operation and the course substantiated the necessity for definitive surgical attack on all cases of recurring hemorrhage and the uselessness of temporizing procedures.

Further indication for emergency operation is sudden hemorrhage deep in an extremity into a false aneurysm which produces swelling and shuts off circulation to the distal part of the extremity and makes urgent immediate operation—a situation which obtained in four of our cases.

Of course, rupture of an aneurysm presents a dramatic indication for operation. In two cases there was rupture, one of an arteriovenous aneurysm to the exterior and one of a subclavian false aneurysm subcutaneously. Fortunately, in each case it was possible to apply emergency pressure until the patient could be taken to the operating room.

CASE 8—A S received a bullet wound in the right groin, just below Poupart's ligament, which made its exit in the lower part of the right buttock posteriorly. Both of these wounds healed promptly but he continued to have pain and when he was seen about four weeks after injury he presented a pulsating mass 4 cm. in diameter in the right groin with a palpable thrill and audible bruit. This was just below the site of the wound of entrance and the mass was very superficial and thin walled. He also had an incomplete lesion of the sciatic nerve with partial posterior tibial and peroneal defect. At six weeks while still in bed this mass ruptured to the exterior with massive hemorrhage which was controlled by a corpsman who at once applied pressure until the patient could be taken to the operating room. At operation a tape was placed about the external iliac artery which, due to the marked collateral circula-

months before operation while the arteriovenous fistula was closely observed. Closure exercises were carried out by the patient through this period in the manner shown in Fig 3 and the size of the lesion showed a marked decrease prior to the time of operation. Compression of the lesion was begun at fifteen minutes, three times a day, and gradually increased to one hour, four times a day. This was checked with a stethoscope and was effective in completely shutting off the flow of blood through the femoral artery. The weight of the man's leg was adequate to accomplish this. At first the closure produced marked cyanosis in the leg and foot and some discomfort, but this improved gradually day by day so that just prior to operation interruption of blood flow through the lesion produced practically no objective change in the color of the extremity and was accomplished with no discomfort to the patient. He was operated upon eleven weeks after injury under a tourniquet placed about the upper thigh. The sac was identified lying just mesial to the femoral vessels, and division and ligation of the artery and the vein both proximally and distally were carried out with excision of the vascular segments, the fistulous tract, the aneurysmal sac, and a great many collateral veins which entered the lesion from below. This man had a smooth postoperative course and was evacuated to the United States, ambulatory and asymptomatic.

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improvement during the preoperative period of observation has been almost negligible and that restoration of function following operation which removed the cause of local infiltration of the tissues including the nerve trunks has been very disappointing. Follow-up reports by letter were obtained from many of this group of patients and the ultimate results are in accord with this opinion. Late operation in the United States was done in one case of subclavian aneurysm with exploration of the brachial plexus and lysis of the nerve trunks but without significant improvement.

Elkin and Woodhall reported, from an Army general hospital, twelve cases of associated neural and arterial damage and emphasized a conservative attitude with regard to the technical procedure on such injured nerves. They bring up the point from their experience that nerve damage may decrease during the preoperative time of observance before arterial operation is done.

OPERATIVE TREATMENT

The operative problems of arterial injury are obviously divided into those associated with the primary emergency treatment of the injury in the field and those associated with the management of the complications of these injuries as they are seen in hospitals to which the casualties have been evacuated. The problem at the front of immediate repair of arterial injury by suture, with grafts, and the use of the Blakemore tube has not been presented in this group.

Most of the patients in the series herein reported were seen from ten days to several weeks after injury and the problems therefore concern themselves with the management of the late complications of incomplete arterial lacerations. In this series, operation was done on twelve false aneurysms, five arteriovenous fistulas, and in four cases of hemorrhage.

With regard to the operative procedure, several factors have been found to be of major importance. The first is the necessity for perfect control of bleeding which should always be secured in advance except where it is anatomically impossible. Although the opinion is generally held that a tourniquet should not be used, it is helpful to have a blood pressure cuff strapped in place on the extremity, where it may be inflated promptly if necessary. Several of the patients were operated upon with the blood drained from the extremity and the tourniquet inflated and this procedure was found to be of great help. Where the tourniquet is not used or where the location makes it impossible, the placing of a tape or rubber tubing about the surgically exposed main artery proximal to the lesion is essential. The artery can usually be isolated and controlled at a distance from the lesion. This should be the first step of every operation and the mass should never be approached or opened without this precaution. With an incomplete laceration of an artery with or without a false sac or with a fistula, the vessel should never be ligated in continuity. This type of ligation of any larger artery is dangerous because of the fact that there is no stump to retract and because of the likelihood of late erosion and hemorrhage or restoration of the continuity of the lumen of the vessel, both of which complications are not uncommon. Furthermore ligation in continuity should be avoided because of its

effect in increasing the peripheral vasospasm including many collateral channels farther down in the extremity. No clamp should be tied which has been blindly placed and, although effective in stopping the bleeding, has not been placed on the artery under direct vision. The artery should be divided, in partial laceration, at the site of the injury, or, in aneurysm, at sites selected proximal and distal to the lesion, and both ends doubly ligated with silk. The accompanying veins should be ligated in all cases in which the circulatory efficiency of the extremity is in the least doubt. A good rule is to do this unless after division of the artery a positive Henle-Coenen test shows a pulsation in the distal stump indicating good circulation.

The sac in false aneurysms may or may not be resected, depending upon local conditions. The primary consideration here is the added operative trauma necessarily resulting from resection of the sac and the consequent increase in postoperative edema and swelling which has a directly deleterious effect upon the channels of collateral circulation by pressure. In cases of borderline circulatory efficiency this should be carefully avoided and all dissection and handling of tissue reduced to a minimum. Furthermore, the sac is very likely to be in intimate relationship to nerve trunks which may be injured further in the procedure. Our plan has been to deal with the artery both proximally and distally and then open the sac and evacuate the clot. In some small aneurysms the sac may be opened directly, the laceration in the arterial wall demonstrated, and division of the artery done at this point.

In the arteriovenous aneurysm, as is well known, a four-way ligation of the artery and vein with division of these vessels, removal of the sac, the fistula, and interruption of all the collateral channels is the only procedure which will give a cure. It is surprising to find the number of collateral channels in connection with an arteriovenous lesion which seem to spring up from every side. Because of these, simple ligation without excision will give an immediate recurrence of the lesion, and proximal ligation of the artery, of course, always leads to gangrene in the extremity. In some arteriovenous aneurysms in unusual locations where resection is impossible technically, procedure has been reported in which a four-way ligation was used coupled with direct transvenous obliteration of the fistula.

Of course, the interruption of sympathetic impulses to an extremity where the efficiency of collateral channels may be in doubt is of the greatest importance to the surgeon operating upon these lesions, particularly in cases in which operation must be undertaken as an emergency before time has elapsed for proper development of collateral channels. This may be accomplished either through direct thoracic or lumbar sympathectomy when practicable or by injection of the dorsal or lumbar sympathetics with novocain immediately at conclusion of the operation and frequently thereafter as indicated. In some cases preoperative tests may be made of the circulatory efficiency by digital interruption of the arterial flow in the main vessel to an extremity proximal to the lesion. Of course, the ligation of the common carotid should always be approached with great caution. Dandy stated that compression for ten minutes with observa-

tion for the appearance of symptoms will give a true indication as to whether or not ligation can be done, and when necessary he has used a strip of fascia lata twice around the artery with partial compression for from seven to fourteen days before ligation. In a series of 600 cases reported by Pilz there were symptoms in 32 per cent. Probably the best rule is that over the age of 40 years, and in all persons with arteriosclerosis, the procedure should be seriously regarded and stage closure done.

In this series of cases the time of operation was from three to eleven weeks following injury. Those that were operated upon after the shorter interval were those demanding emergency procedures. It is possible that in some cases periods longer than two months might be needed in preparation for operation.

It was our good fortune to have only two amputations in this series. The first of these is reported in Case 10.

CASE 10—R. L. received a stab wound of the right upper thigh for profuse hemorrhage. Immediate exploration was done and the common femoral artery and the deep femoral vein were ligated. He was admitted to the hospital seven days after operation with a line of demarcating gangrene at the mid calf. The leg was refrigerated and after several transfusions was amputated in the mid lower region.

The second amputation is described in Case 11.

CASE 11—D. G. received a through and through machine gun bullet wound in the back of the right knee and was admitted three days later with a very tightly swollen leg with grade IV swelling and induration from above the patella to the lower calf, extreme pain, no palpable pulsations below the femoral artery, and early gangrene of the foot with cold blue skin in the distal half and in the heel. He had a hemarthrosis of the knee. Immediately upon admission he was taken to the operating room and a long releasing incision made in the fascia of the calf posteriorly to relieve the pressure to the full extent of the leg. This was packed open and the sympathetics blocked. Pulsation appeared in the popliteal artery following this procedure but there was no change in the level of discoloration in the foot. Ten days later examination disclosed in the wound in the lower popliteal space a pulsating mass with a thrill and a continuous bruit and it was apparent that an arteriovenous aneurysm had appeared in this location. The skin edges by this time were widely separated and the wound was granulating and not obviously infected. A closure of this lesion by pressure produced a rise in the blood pressure and a slowing of the pulse. It was thought that any procedure that might bring an interruption of the leak into the venous system and which would increase the pressure in the collateral branches past the knee would be of benefit. Accordingly, he was reoperated upon and a four way excision of an arteriovenous fistula of the popliteal artery was performed. However, this produced no change in the circulatory status of the foot and a guillotine amputation was performed in the mid lower region of the leg, following which there were no further complications.

The phenomenon of traumatic vasospasm is a very interesting one. Its nature is self-explanatory and it appears first as a compensatory mechanism to combat hemorrhage probably with its mode of action through sympathetic hypertonus. However, this effect may persist after the injury for as much as forty-eight to seventy-two hours and give quite undesirable effects in the prolonging of ischemia of the extremity. Actually this effect may spread from the affected extremity to other regions in the body, and it has been demonstrated to occur in sufficient degree to affect the circulatory balance even when the wound

In another patient there was found, in a case of arteriovenous fistula of the common carotid, an associated true arterial aneurysm of the vessel wall adjacent to the fistula



Fig 4—Roentgenogram six weeks after resection of clavicle for exposure of subclavian aneurysm showing bone regeneration (Case 13) At this time clavicle was clinically solid and arm function good

CASE 14—G C received a bullet wound through the neck. The findings on admission showed a pulsating fullness just beneath and lateral to the right sternomastoid muscle. There was a continuous thrill with systolic accentuation readily palpable. There was a loud continuous audible bruit. Closure exercises were done on this man with great care during the two and one half months he was kept under observation on the ward. He used an apparatus which was devised, similar to the Matas compressor, and also used a padded dowel to interrupt the circulation for intervals which began at two minutes, which was as much as he could tolerate without headache and dizziness at the onset, but were carried up to thirty minutes. Finally, during complete closure of the fistula and the common carotid artery, during a thirty minute period by the operator, he developed no cerebral symptoms whatever and it was felt safe to proceed with operation. This patient had an arteriovenous channel and, in addition, through the weakened wall of the artery at the same level there had developed a true arterial aneurysm, of which section showed media and intima in the wall of the aneurysm. The tip of this aneurysmal sac was densely adhered to the thyroid gland and consequently it was partially amputated at operation. This represents an unusual complication of this type of injury. The postoperative course was uneventful and the patient was evacuated in excellent condition.

Brief partial notes concerning remaining cases are added here

CASE 15—K. S. had a through and through mortar shell fragment wound of the left hand with severe hemorrhage controlled by pressure. Marked pain persisted and he was admitted to the hospital fifteen days after injury, when at dressing a severe profuse hemorrhage appeared from a wound of the hypothenar eminence which was controlled by tight pressure. Seven days later, with continuing severe pain, a small pulsating mass was noted under the scar which was very tender. This was treated conservatively with splinting and ten days later marked improvement had appeared and the pulsation was noted to have disappeared. Recovery was uncomplicated. This represented a false aneurysm of ulnar artery which healed spontaneously.

CASE 16—In L. O., a false aneurysm of the ulnar artery in the palm from a stab wound appeared four days after injury. He was operated upon with isolation and excision of the aneurysm and had a smooth recovery.

CASE 17—R. L. had a false aneurysm of the mid portion of the radial artery from a grenade fragment wound at the middle third of the lower surface of the right forearm, which presented two weeks after injury a 3 cm. pulsating mass with a systolic bruit. The wound was allowed to heal completely and a false aneurysmal sac was dissected out and excised with division and ligation of the radial artery above and below the sac. The deep branch of the radial nerve was adherent in the scar at the base of the mass and was freed. There was a small area of anesthesia on the lateral surface of the thumb, which was not influenced by operation.

CASE 18—G. M. had a false aneurysm of the axillary artery which developed following a bullet wound through the shoulder with partial defects from injury of all trunks of the brachial plexus. Three weeks after injury a pulsating mass 5 cm. in diameter was found below the outer end of the right clavicle with a short audible systolic bruit. Blood pressure was equal in both arms. He gradually recovered partial motor power in the muscles of the right arm and hand and the aneurysm slowly decreased in size under observation. He was evacuated for operation.

CASE 19—T. L. had a false aneurysm of the axillary artery from a rifle bullet wound of the shoulder with evidence of pulmonary injury immediately after he was hit. There was a left hemothorax which required two aspirations, and several fractured ribs. He was admitted five weeks after injury with limited excursion of the left chest and a much thickened pleura. The wounds were healed. There was a 4 cm. diameter pulsating mass under the pectoral fold, presenting anteriorly and also in the axilla, systolic bruit and thrill, and moderate tenderness. There was partial median nerve defect and a palpable difference in the radial pulses. Under observation this mass became smaller and the patient was evacuated to the U. S.

CASE 20—R. C. had an arteriovenous fistula of the common carotid from a wound by a small shell fragment which produced immediate hoarseness and local swelling and pain. Examination two days after injury showed a laceration over the anterior border of the left sternomastoid muscle, a pulsating mass 4 cm. in diameter with a loud continuous bruit and a continuous thrill was felt below this. The trachea was displaced to the right. There was a left recurrent nerve paralysis. Gradual improvement in the local signs and symptoms followed during the one week in which he was observed, although the temporal pulse became progressively weaker. The changes in pulse and blood pressure in this case are indicated in Table II. This man was seen in a forward unit, where it was not possible to retain him for observation and operation.

CASE 21—L. D. had a 2 cm. pulsating subcutaneous mass in the right supraorbital area which was seen eight months following a blow on the forehead. This was excised and a small arteriovenous cirroid aneurysmal mass was found.

CASE 22—In R J, ten days following a small fragment wound of the anterior part of the right calf, there appeared suddenly a hard, tense nonpulsating mass over this area, extremely painful. Systolic bruit was heard. Prior to this time the possibility of an abscess had been entertained and at operation the sac of a false aneurysm was opened and the artery divided and ligated.

CASE 23—D M had a false aneurysm of the anterior tibial artery which presented a pulsating mass anteriorly just below the knee. It increased gradually in size and became more painful, at operation it was found to originate from the artery just as it came between the tibia and fibula. The sac was excised and the artery divided and ligated. There was partial peroneal nerve defect but the nerve was not explored at the time of operation.

CASE 24—F S received a mortar shell fragment wound of the lower leg. Ten days after injury there appeared sudden swelling of the mesial side of the posterior surface of the leg and a pulsating mass which became painful. Operation was done after fourteen days and a false aneurysm of the posterior tibial artery was found and excised.

CASE 25—R L had recurrent hemorrhage from the posterior tibial artery after receiving a machine gun bullet wound. Fifteen days after injury while in transit he had a sudden severe hemorrhage of the wound. On admission on the seventeenth day there was some continued bleeding and he was operated upon at once. The leg was widely opened and partial laceration of the artery found. It was divided and ligated. He had a smooth subsequent course.

SUMMARY

The interesting features of a group of twenty-five cases of vascular injury seen in the South and Central Pacific campaigns are pointed out.

It is the partial or incomplete laceration of the vessel which prevents spontaneous cessation of hemorrhage, and leads to the complications described—recurrent hemorrhage, false aneurysm, arteriovenous fistula, and arteriovenous aneurysm.

In the handling and evacuation of casualties, these lesions are frequently overlooked in the presence of small clean perforating wounds of the extremities, and only careful examination with auscultation will reveal their presence.

An extensive sterile inflammatory reaction simulating cellulitis is not infrequently a characteristic of false aneurysm, in which case the differential diagnosis is of the utmost importance.

The common tendency of these lesions is toward spontaneous partial healing and decrease in size, but the exceptions in which sudden hemorrhage or rupture occurs make very close observation necessary in cases in which operation is delayed, and emphasize the inadvisability of evacuation, particularly in false aneurysms, before definitive surgery is done. Emergency operation is not infrequently required.

The cases of recurrent delayed hemorrhage from a partially lacerated deep artery demonstrate the dangers of temporizing procedures in such situations and the need for formal exploration, visualization, and division of the artery.

The collateral circulation was found surprisingly effective in this group of young men.

Points concerning the operative procedure are considered and the physiology of arteriovenous fistula is reviewed.

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REFERENCES

- Elkin, D C, and Woodhall, B Symposium on Vascular Surgery, Combined Vascular and Nerve Injuries of Warfare, *Ann Surg* 119 411 431, 1944
- Harbison, S P Experiences With Aneurysms in Overseas General Hospital, *Surg, Gynec & Obst* 81 128 137, 1945
- Elkin, D C Vascular Injuries of Warfare, *Ann Surg* 120 284 310, 1944
- Beck, W C "Pulsating" Hematoma (False Aneurysm), *War Med* 4 502 507, 1943
- Dandy, W E Results Following Ligation of Internal Carotid Artery, *Arch. Surg* 45 521 533, 1942
- Bigger, I. A Treatment of Traumatic Aneurysms and Arteriovenous Fistulas, *Arch Surg* 49 170 179, 1944
- Wise, R A Symposium on War Surgery, Traumatic Arteriovenous Aneurysm, *S Clin North America* 23 1527 1543, 1943
- Holman, E War Injuries to Arteries and Their Treatment, *Surg, Gynec & Obst* 75 183 192, 1942
- Holman, E Clinical and Experimental Observations on Arteriovenous Fistulae, *Ann Surg* 112 840 875, 1940
- DeBakey, M Traumatic Vasospasm, *Bull U S Army M Dept* (No 73) pp 23 28, 1944
- Pilz, quoted by Holman, E War Injuries to Arteries and Their Treatment, *Surg, Gynec & Obst* 75 181, 1942

DERMATOLOGIC ASPECTS OF AMPUTATION STUMPS

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PROPER care of the skin of the stump is of great importance. The skin must be able to tolerate the procedures¹ necessary to prepare for prosthesis, otherwise the conditioning will be prolonged and adverse psychologic factors, already severe, will be greatly aggravated. Then, after fitting, it must be able to withstand the daily abuse in an environment for which it was never intended, or the person will be greatly handicapped, when skin disorders begin, use of prosthesis stops.

The consideration of the skin begins immediately after operation. Adhesive tape is usually used to bind the stump and unfortunately, many people are sensitive to it. If it is observed that an irritation develops corresponding to the sites of its application, the tape should be removed. After allowing the inflammation to subside, elastoplast,* an excellent elastic adhesive dressing, could be tried but some patients, sensitive to adhesive tape, are also sensitive to elastoplast. Hence, it is best to change to Scotch tape, this product has a much lower percentage of sensitization. If the postoperative irritation does not conform to the outlines of the tape, it has probably been caused by the antiseptic or the sulfa drugs. That being the case, those preparations should be thoroughly removed and a bland ointment applied until the inflammation subsides.

In the conditioning stage, several procedures are to be avoided lest they delay the toughening of the skin. Cool or warm whirlpool baths^{2, 3} are tolerated well if used for short treatments, but hot water and long periods, that is over fifteen minutes tend to soften the skin. For those who advocate massage, the use of a lubricant is warned against, alcohol is permissible if care is taken to avoid chafing the skin. A nicely dried skin becomes toughened and resists infection much better than an oily or soggy skin.

When the skin has been conditioned to receive prosthesis, it is up to the patient to observe strict hygienic measures^{4, 5}. It must be cleansed daily with soap (nonmedicated) and water and, in addition, must be exposed to the air and sun whenever possible. In a dry climate, particularly in the winter, it is possible by too thorough or too frequent washings to cause severe chapping. A superfatted soap, such as Basis Soap,† or a soap substitute, as Acidolate‡ or Lowila,§ may be beneficial. In this stage, alcohol is advised against⁶ since it tends to dry the skin. On the other hand, the use of any oily or greasy substance should be avoided if possible, it predisposes to folliculitis. When the prosthesis is worn, the stump is covered with a daily-laundered

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*Supplied by Duke Laboratories Stamford Conn

†Duke Laboratories.

‡Rare Chemicals, Inc. Flemington N J

§Westwood Pharmacal Corp, Buffalo N Y

virgin wool sock⁷, in some few instances the physical irritation properties of wool are sufficient to cause change to white cotton. One or more socks are worn according to the fit in the socket. When too many socks are used, the stump will not bear the proper relations with the prosthesis. An anhydrotic antiseptic dusting powder is recommended, one consisting of 2 per cent aluminum acetate and 10 per cent powdered boric acid in talc is excellent. If the patient tends to perspire freely, $\frac{1}{4}$ per cent thymol iodide may be added temporarily. "Skin tougheners" and strong astringents should not be employed⁸, then composition is often questionable as to ingredients and as to the strengths thereof. The changes they produce are usually more detrimental than advantageous. One should know exactly what is being used on the stump and know that it will be beneficial, otherwise its use should not be allowed. If such care is observed, the majority of patients will have no trouble.

The pathologic conditions which do develop may be divided into three groups. The first to be considered is that caused by the stump. A poorly developed scar is an example³. If the scar is not pliable, soft, and unattached to the deeper structures, ulceration may develop. Keloid formation, which frequently causes irritation and hence ulcerates easily, is found more often in the sagittal scar than in the transverse⁸. Scars adherent to the bone, even though thin and papery, are less likely to ulcerate because there is no piston action communicated to them, on the other hand, a scar with much muscle tissue between it and the bone has too much motion and often develops trouble. Most authors⁵ recommend that only subcutaneous tissue and the fascia of the muscle separate the scar and bone. If ulceration develops in an abnormal scar, in a scar adherent to the bone, or in skin which has become too tight, reamputation is usually indicated,⁴ otherwise a full-thickness or pedicle flap may be used. Pinch or Thiersch grafts are employed but are not as satisfactory. Non-surgical treatment is rarely of lasting benefit.

Folds develop when there is a redundancy of tissue. This may be due to faulty surgery or to a change in the patient's weight. These intertriginous areas make perfect breeding grounds for bacteria. The areas first macerate, then become infected. This may remain an intertrigo⁹ or develop into an infectious eczematoid dermatitis which can cover the entire stump. The environment is ideal also for a monilia infection. Skin tabs may cause results similar to those caused by the folds. These underlying conditions require surgical correction.

The second group includes those conditions due to the prosthesis. Friction burns are common, especially when the limb is first fitted. Calluses¹⁰ and areas of lichenification result from unequal distribution of weight or from the bearing of weight on improper areas. Pressure boils and ulcers may develop instead of or associated with calluses. The boils are particularly common on the adductor surface of the thigh as a result of an ill-fitting ischial seat for a thigh amputation. Correction of these conditions depends upon the readjustment of the prosthesis.

The third group consists of those conditions resulting from the association of the stump in the socket. The commonly seen furuncles^{10 11} and folliculitis

especially found in men are in this group, as are the infected sebaceous cysts and infectious eczematoid dermatitis (which is also in the first group). Localized miliaria (heat rash) may develop during warm weather or in warm environment. The stump may become involved in a Trichophyton or Epidermophyton infection, Monilia infection may develop, although this is more probable if folds are present. Treatment for these conditions depends upon the specific instance. In general, soothing antiseptic soaks, that is, boric acid solution, Burow's solution, or potassium permanganate solution, are indicated when used for periods of fifteen minutes' duration three or four times per day, although for massive infection it may be necessary to ignore the softening effect on the skin and use continuously. An antiseptic powder or powdery shake lotion then may be used after each soaking, if there is little or no weeping. Otherwise, it is necessary to follow with an antiseptic incorporated in a water-absorbent ointment base such as Aquaphor or Lassar's paste. Tal is avoided as it is likely to cause follicular irritation. Exposure to air and sunlight is very beneficial and the use of superficial x-ray therapy, ultraviolet light, or cold quartz ray will usually shorten the recovery period.

One important consideration regarding drugs must be discussed. The treatment of the stump may be a rather extended or repeated procedure, thus affording excellent opportunities to develop a sensitivity. For that reason, drugs should be avoided which are high on the list as sensitizers, notably sulfa drugs,^{12, 13} mercury, benzocaine, nupercaine, picric acid, butesin picrate, amino-benzene, and chlorbutanol. Instead, such substances may be chosen as boric acid, aluminum acetate, potassium permanganate, or xeroform. Incidentally, penicillin has been reported¹⁴ to have as high a sensitivity as 5 per cent. A chemical contact dermatitis on a stump is often a severe situation which may be very incapacitating and, more important, may lead to the development of additional sensitizations. A sensitivity may develop even to the material of the prosthesis, or, more correctly, to the processing substances in the prosthesis material. A stump, the skin of which has developed multiple sensitivities, is a constant source of trouble.

Generalized skin disorders, such as psoriasis and lichen planus, may develop on the stump. Because of the factor of trauma, the disease may be manifest on the stump and nowhere else. This situation calls into play accurate dermatologic judgment.

In summary, it is noted that the best treatment of possible skin disorders is the unrelenting prophylactic general hygienic care to the stump. Disorders which do develop are divided into three groups, namely, those due to the stump, those due to the prosthesis, and those due to the interrelation of the two. A skin complaint, even though minor, can prevent use of the prosthesis with all the resulting incapacitations.

REFERENCES

- 1 Brunnstrom, Signe. Physical Therapy in Aftercare of Amputations of Lower Extremity, U S Nav M Bull 43 634-644, 1944
- 2 Titus, Norman Edwin. Physical Therapy in the Treatment of Amputation Stumps, S Clin North America 18 483-485, 1938

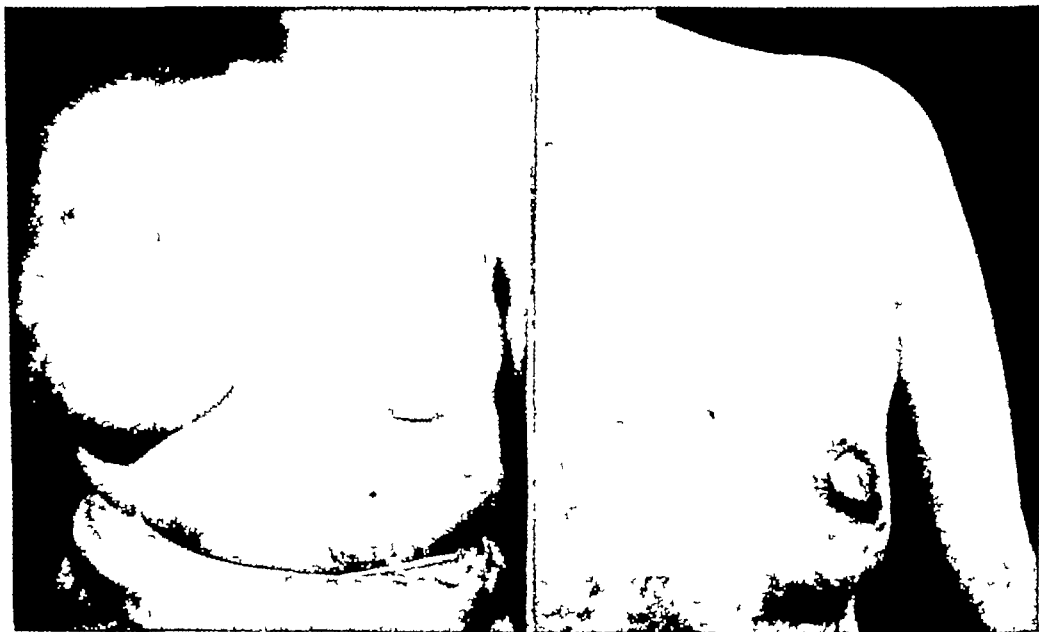
- 3 Rudolph, Herman L Physical Therapy in After Treatment of Amputations, *M Clin North America* 27 1109, 1943
- 4 Sullivan, John E The After Care of Amputation Stumps, *S Clin North America* 18 433 440, 1938
- 5 Thompson, V P The Amputation Stump From the Prosthetic Point of View, *J A M A* 124 1036, 1944
- 6 Thomas, Atha, and Haddan, C C Amputation Prosthesis, Philadelphia, 1945, J B Lippincott Company
- 7 Thomas, Atha The Permanent Prosthesis, *J A M A* 124 1044 1046, 1944
- 8 Langdale Kelham, R D Amputations and Artificial Limbs, London, 1942, Oxford University Press
- 9 Mitchell, W R D The After Care of Amputations, edited by Doherty, W B, and Runes, D D, Rehabilitation of the War Injured, New York, 1943, Philosophical Library, Inc
- 10 Kirk, Norman T Amputations, Chapter 10 in Volume III, Lewis' Practice of Surgery, edited by Walters, Waltman, Hagerstown, Md, 1945, W F Prior Company, Inc
- 11 Colonna, P C, and vom Saal, F Amputation Stumps of the Lower Extremity, *J A M A* 113 997, 1939
- 12 Cole, Harold N The Local Use of Sulfonamide Compounds in Dermatology, *J A M A* 123 411, 1943
- 13 Lane, Clinton W Observations on the Topical Application of the Sulfonamides, *South M J* 38 125 132, 1945
- 14 Cohen, T M, and Pfaff, R O Penicillin in Dermatologic Therapy—Report of Results in One Hundred Cases, *Arch Dermat & Syph* 51 172, 1945

CONSTRUCTION OF PSEUDOAREOLA

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THE areola is usually lost in complete amputation of the breast (Fig 1, *A*). The breast may be built up by a derma-fat-fascia transplant* to form a normal contour, but will not give an esthetic appearance because of the absence of the areola. I have devised a new method of constructing a projection resembling the nipple in size and shape (Fig 1, *B*).

A circular incision of the required size is made with a tiephine over the apex, through the epithelium, to the derma of the skin (Fig 2, *A*). The epithelium is undermined from the periphery to 1 cm. of the center, exposing the dermal surface of the skin (Fig 2, *B*). The loose epithelium, which is shrunk, is stretched, and three identical triangular sections are excised (Fig 2, *C*).



A

B

Fig. 1—*A*, Patient before operation. Note complete absence of breast and areola. *B*, Patient after operation. Breast rebuilt with derma-fat-fascia transplant and pseudoareola constructed.

The margins of the triangles are sutured together (Fig 2, *D*), forming a nipple like oval projection, with a slight indentation in the center. The base of the epithelium is attached to the derma with fine, interrupted silk sutures. These sutures at the base produce the elevation and shape of a nipple (Fig 2, *E* and *F*).

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*Berson, Morton I. *Derma-Fat-Fascia Transplants Used in Building Up the Breasts*, *Surgery* 15: 451-456, 1944.

This operation produces a definite nipplelike projection. When the circular area of the derma is epithelized, a dark and mottled shade different from the surrounding skin is produced, thereby giving the appearance of areolae.

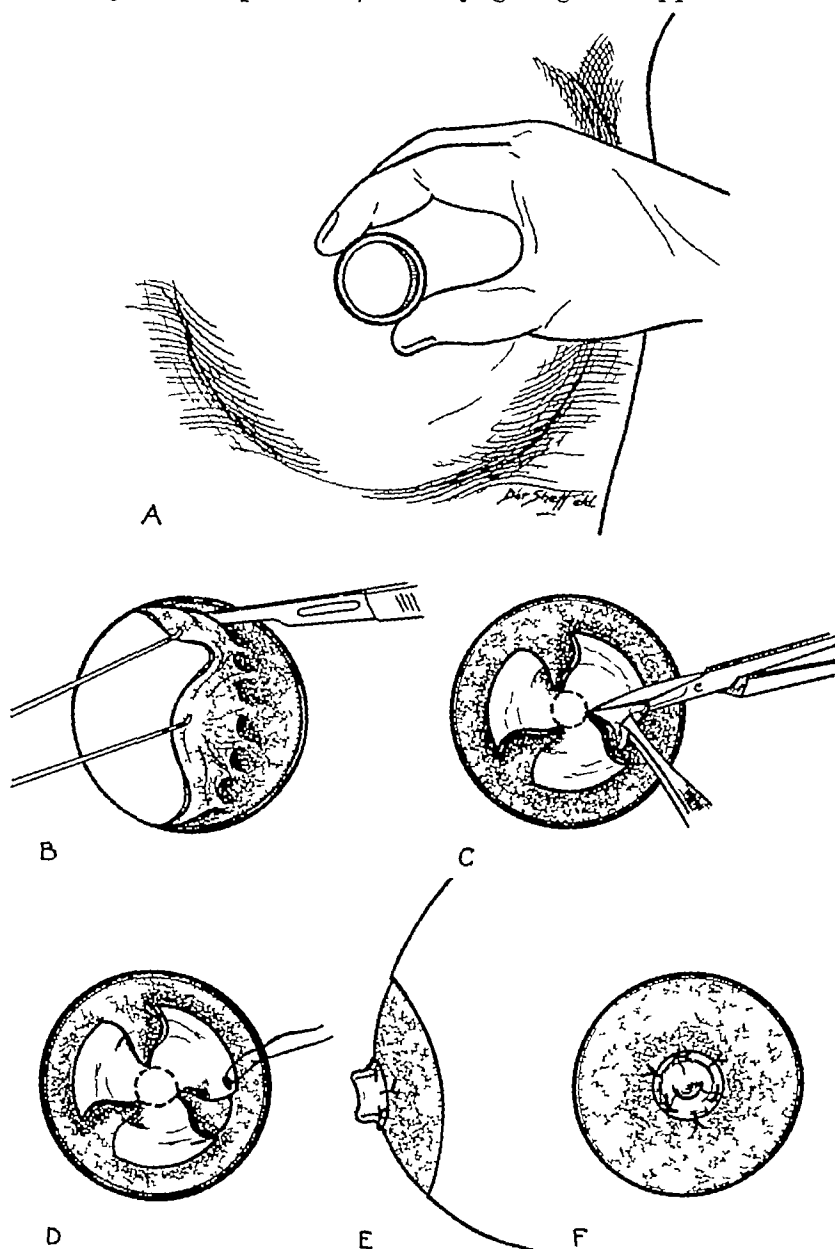


FIG. 2.—Method for constructing pseudoareola.

tissue. The pseudonipple can be constructed at the same time a breast is being rebuilt, and the same method can be used in other cases where function is not a factor.

PRIMARY TORSION OF THE OMENTUM

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PRI-MARY or idiopathic torsion of the great omentum is a rare pathologic entity which is seldom recognized preoperatively. It occurs frequently enough, however, to require consideration in the differential diagnosis of acute abdominal lesions producing pain. In practically all of the cases reported, the preoperative diagnosis has been acute appendicitis, the symptom complexes of the two conditions being quite similar and often identical.

Torsion of the omentum may be defined as a rotation of the whole or a part of that structure upon its long axis. The extent of the twist may or may not be such that the blood supply of the distal portion is impaired, but it is with the former situation that we are most concerned since it produces the signs and symptoms of an acute abdominal catastrophe.

Two principal types of omental torsion have been described, namely, the primary or idiopathic and the secondary. Primary torsion implies the absence of any recognizable etiologic factor such as hernia, neoplasm, adhesive bands, or inflammatory processes, while torsion in the presence of any such pathologic process is classified as secondary. Of the classifications of omental torsion, that of Teller and Baskin¹ is simple and logical.

A Primary (pure, true, idiopathic)

- 1 Simple torsion
- 2 Torsion with herniation of mass through omentum itself

B Secondary

- 1 Hernial
- 2 Hernio-abdominal
- 3 Abdominal
- 4 Pelvic
- 5 Combined

The present report is concerned exclusively with the primary type of omental torsion, a lesion much less common than the secondary type. The first case of primary torsion of the omentum was reported by Eitel² in 1899. In 1932, Morris³ studied forty-one such cases collected from 1905 to 1932 and cited six other cases reported by Corner and Pinches in 1905. Lipsett⁴ in 1941 reviewed the reports appearing after 1932, collecting ten cases and adding one personal case. Since 1941, six other cases⁵⁻¹⁰ have been recorded, bringing the total number of recorded cases to sixty-four. In contrast, the known number of cases of omental torsion of the secondary type is now well over 250, Morris³ having cited 171 in 1932.

Material—Within the past year we have operated upon three patients who had gangrene of the omentum caused by unexplained torsion and have found three other similar cases, the patients being treated at the Cincinnati General Hospital in the last twelve years. These six cases, and a seventh reported by Andrus¹¹ in 1926, to our knowledge constitute the largest group of this type observed in any single clinic.

CASE REPORTS

CASE 1—C M., a white man 29 years of age, was admitted to the hospital on Feb 23, 1933, with a history of abdominal pain of three days' duration. The onset of the pain had been sudden and followed by nausea without vomiting. Several hours after its onset, the pain localized in the right lower quadrant of the abdomen, where it persisted and increased in severity until the time of admission. Two hours before entrance into the hospital, the patient had been given a hypodermic injection of morphine for the relief of the severe pain. There was no history of constipation, diarrhea, or previous attacks, but there was slight burning on urination following the onset of the abdominal pain.

Examination showed a well developed, well nourished young man who obviously was in pain. Temperature was 100° F and pulse 106. Examination of the head, neck, and chest was essentially normal. The abdominal wall moved with respiration. Tenderness localized at McBurney's point, rebound tenderness referred to the same area, and voluntary muscle spasms were easily elicited. There was no tenderness in the costovertebral angles. Rectal examination showed moderate tenderness high on the right side with slight tenderness on the left.

Laboratory examinations showed the urinalysis to be essentially negative and the white blood count to be 20,000 per c mm.

A diagnosis of acute appendicitis was made and under ether anesthesia, operation was performed through a McBurney incision. No free fluid was encountered. The appendix was found to be bound down by numerous fibrous adhesions, but showed no signs of acute inflammation. Appendectomy was performed in the usual manner and the ligated stump was inverted by means of a purse string suture of fine black silk. Further exploration through the McBurney incision showed a small amount of sanguineous fluid in the pelvis, but no mass could be palpated there. In the right upper quadrant, an indurated mass was located and delivered into the wound by gentle manipulation. The mass consisted of a discolored and gangrenous portion of the omentum measuring approximately 6 by 6 by 4 cm. The mass had undergone seven complete twists on its neck. The involved area was amputated and the stump transfixed with medium black silk. The wound was then closed in layers without drainage, using catgut as the suture material.

Pathologic examination of the omental mass showed dilatation of the small veins and capillaries with thrombosis of the larger vessels, hemorrhagic extravasation, and extensive necrosis.

The course in the hospital was uneventful, the wound healed kindly, and the patient was discharged on March 4, 1933.

CASE 2—A M., a 40 year old white woman, was admitted to the hospital with a history of pain in the right lower quadrant of four days' duration without nausea or vomiting. The pain had subsided one day after onset, but recurred on the following day. It was of a cramping nature, and persisted until the time of admission. There was no history of constipation but the appetite was poor. There had been no previous similar gastrointestinal symptoms. The patient was also pregnant, the last menstrual period having been three months before.

Examination showed an obese white woman who did not appear acutely ill. Temperature was 99.4° F, pulse 88, and respirations were 24. The pharynx was slightly injected and the heart and lungs were normal. The blood pressure was 135/75. The abdomen showed moderate rigidity of the right rectus muscle, tenderness localized to McBurney's point, and rebound

tenderness referred to the same point. No masses or evidence of hernia were found. The pelvic examination showed an enlarged uterus with a soft movable cervix and moderate tenderness high in the right adnexal region.

The urinalysis was essentially normal and the leucocyte count was 10,200 cells per c.mm.

A diagnosis of acute appendicitis was made, but because of the atypical features of the case, the patient was observed for twelve hours during which the white blood count rose to 12,800 and the pain became more severe.

Operation was then performed through a McBurney incision under general anesthesia. A moderate amount of blood tinged fluid escaped into the wound from the peritoneal cavity. The appendix was found to be normal in appearance. Appendectomy was done in the usual manner, the ligated stump being inverted by means of a purse string suture of fine black silk. Examination of the terminal ileum revealed no abnormalities. Both ovaries were normal. A hard mass felt in the right upper quadrant was drawn into the wound with ring forceps. It consisted of a piece of discolored omental tissue measuring approximately 4 inches in diameter by $\frac{3}{4}$ inch in thickness. It was hemorrhagic in appearance and seemed to be undergoing early gangrenous changes as the result of strangulation produced by twisting of its narrow pedicle. The mass was amputated by dividing the pedicle between Kelly clamps and transfixing the stump with a suture of medium silk. The wound was then closed without drainage, using silk.

Pathologic examination showed the specimen to consist of a flat oval shaped mass of omentum which was soft and reddish black in color and measured 6.5 by 7.5 by 1 cm. In its upper portion, there appeared to be a 360 degree twist of the narrow neck where the mass had been amputated. Distal to the neck the mass was gangrenous. The appendix was normal.

The patient's course in the hospital was uneventful. The wound healed well and she was discharged on Sept. 22, 1936.

CASE 3—H. A., a 34 year old white man, was admitted to the hospital on March 22, 1942, with a history of left sided abdominal pain of three days' duration. The pain of gradual onset became generalized and cramping in nature within twenty four hours. On the day before admission the discomfort localized in the right lower quadrant of the abdomen and was exaggerated by deep breathing or movements. Appetite was poor, but there was no vomiting. He had had no previous similar attacks.

Physical examination showed a well nourished white man who appeared to be in moderate pain. Temperature was 100° F, pulse 106, and respirations were 25. The examination of the head, neck, and chest was not remarkable. There was marked tenderness localized over McBurney's point and laterally above the crest of the ileum with rebound tenderness referred to the same area. No abdominal masses were palpated. The abdomen was not distended and peristaltic sounds were of diminished intensity. Rectal examination revealed moderate tenderness high on the right side.

Laboratory data revealed urinalysis negative. The white blood count was 17,700.

The diagnosis of acute appendicitis was made and under general anesthesia, operation was performed through a McBurney incision. Upon incision of the peritoneum, thin bloody fluid escaped into the wound. Examination of the appendix showed its surface vessels to be slightly injected, but otherwise the structure was normal. The mesenteric nodes of the terminal ileum were moderately enlarged. No Meckel's diverticulum was found. Appendectomy was done in the usual manner, the ligated stump being inverted by means of a purse string suture of fine black silk. Further exploration revealed an indurated mass in the right lumbar gutter. This was delivered into the wound and found to be a mass of omentum discolored by hemorrhage and early gangrene. Its narrow pedicle was found to be acutely twisted upon itself. The pedicle was divided between clamps and transfixed with fine black silk, the mass being removed in this manner. The wound was then closed without drainage using fine black silk as suture material.

Pathologic examination of the omental tissue showed extensive extravasation of blood. Several large blood vessels present in the section showed no evidence of thrombosis. Fibrinous purulent exudate was present along the serosal surface on one margin of the section.

The patient's course in the hospital was uneventful. The wound healed per primam and the patient was discharged on March 29, 1942.

CASE 4—H. A. S., a white man 30 years of age, was admitted to the hospital on May 31, 1944, with a history of severe pain in the right lower quadrant of the abdomen of approximately twenty three hours' duration. The onset of the pain had been quite sudden, but was not associated with nausea or vomiting. The pain was exaggerated by walking, deep breathing, and coughing. There was no history of constipation or diarrhea.

Examination showed a short, obese white man who obviously was having severe pain. Temperature was 99.4° F, pulse 16, and respirations were 24. The examination of the head, neck, and chest was essentially negative. The abdominal wall was thick and protruded beyond the level of the thorax. No obvious masses were palpable. There was marked tenderness associated with rebound tenderness and moderate rigidity in the upper portion of the right lower quadrant of the abdomen. Psoas spasm and costovertebral tenderness were absent. Auscultation of the abdomen showed the presence of normal peristaltic sounds. There was no evidence of hernia. Rectal examination was essentially negative.

Laboratory findings showed the white blood count to be 8,050 with 58 per cent polymorphonuclear leucocytes, 35 per cent lymphocytes, 2 per cent monocytes, 3 per cent eosinophiles, and 2 per cent basophiles. The hemoglobin was 96 per cent and the red blood count was 4,480,000. Urinalysis was essentially normal.

A diagnosis of acute appendicitis was made and operation was performed through a McBurney incision under general anesthesia consisting of cyclopropane and ether. On opening the peritoneal cavity, a small amount of bloody serous fluid escaped into the wound. The appendix was visualized with some difficulty and was found to be retrocecal in position, being bound down by fibrous adhesions. It was removed in the usual manner, the ligated stump being inverted by means of a purse string suture of fine black silk. Further exploration through a Weir extension revealed the terminal ileum and mesentery to be normal. There was no evidence of a Meckel's diverticulum. A discolored portion of the omentum, approximately 6 by 8 cm. in size, was found in the upper part of the right lower quadrant of the abdomen. It was free and unattached to contiguous structures. It was hemorrhagic and partially gangrenous as a result of torsion of its narrow pedicle. The gangrenous mass was removed after division of the base and transfixion of the stump with fine black silk sutures. The abdominal wound was closed in layers without drainage using black silk sutures.

Pathologic examination showed dilatation of the blood vessels with extravasation of red blood cells throughout the fatty tissue. Thrombosis of many of the vessels had occurred and areas of early necrosis were evident.

Postoperatively the patient's course was uneventful. Temperature rose to 101.2° F within twelve hours after operation and then gradually fell, reaching normal forty eight hours later. The wound healed per primam and he was discharged from the hospital ten days after operation.

CASE 5—J. D., a colored man 46 years of age, was admitted to the hospital on April 30, 1945, with a history of abdominal pain of three days' duration. The onset of pain was gradual and occurred while the patient was shoveling coal. The pain gradually increased in intensity, causing the patient to walk in a bent over position and forcing him to quit work the day before admission to the hospital. He complained of nausea, but no vomiting, constipation, or diarrhea. There had been no previous similar attacks and his health had been excellent.

Examination showed a robust and muscular colored man who did not appear to be acutely ill. Temperature was 98.6° F, pulse was 80, and respirations were 20. Examination of the head, neck, and chest was essentially normal. Moderate rigidity with voluntary muscle spasm was present in the right lower quadrant of the abdomen. Point tenderness was elicited over McBurney's point and rebound tenderness was referred to the same area. There was no tenderness in the flank or evidence of hernia. Rectal examination showed moderate tenderness high on the right, no tenderness on the left. Laboratory examination showed the urinalysis to be negative and the white blood count to be 7,050.

Diagnosis of probable acute appendicitis was made and the patient was admitted to the hospital for further observation. The white blood count was repeated in three hours and found to be 10,000 at this time. Operation was decided upon and performed through a small transverse incision under spinal anesthesia. The appendix was located and found to be perfectly normal. No abnormalities in the terminal ileum or its mesentery were noted. No Meckel's diverticulum was present. A firm, immovable, irregular mass was palpated in the right paracolic gutter in the lower portion of the right upper quadrant. The mass was apparently attached to the colon. The right rectus muscle was reflected medially, permitting direct visualization of the mass which consisted of a 3 by 2 by 1 cm portion of dark, red, hemorrhagic omental tissue attached to the remainder of the omentum by a narrow pedicle which was acutely twisted upon itself. The tip of the omental mass was also attached to the anterior surface of the ascending colon by a slender fibrinous adhesion. The adhesion and the pedicle of the mass were individually ligated with fine black silk and divided. Appendectomy was done in the usual manner, the ligated stump being inverted by means of a purse string suture of medium black silk. The wound was then closed with silk without drainage.

Pathologic examination showed that the omental tissue consisted of degenerated fat cells and fibrous tissue which was infiltrated by plasma cells, polymorphonuclear leucocytes, and lymphocytes. There was extravasation of the red blood cells. No normal architecture of the omentum remained.

The patient's course in the hospital was uneventful and the wound healed per primam without evidence of infection. He was discharged from the hospital on May 9, 1945. He was seen later on May 16, 1945, at which time he had no complaints and the wound was found to be well healed.

CASE 6—M L B, a 36 year old white woman, was admitted to the hospital on July 12, 1945, with a history of abdominal pain of twenty four hours' duration. The onset of the pain was sudden and occurred fifteen minutes after lunch. The pain was severe, constant, and localized over an area of moderate size in the right lower quadrant of the abdomen. There had been anorexia and nausea but no vomiting. Urinary frequency was present beginning with the onset of pain. She had undergone three previous operations, including a spinal fusion for tuberculosis of the lumbar spine at the age of 19. No evidence of tuberculosis of the lungs was demonstrated by physical or roentgenologic examination.

Physical examination revealed a white woman who appeared acutely ill and very pale. Temperature was 99.6° F, pulse 90, and respirations were 24. The skin was dry and sallow. A scar was present over the anterior aspect of the left leg and over the lumbar spine. Examination of the head and neck was essentially negative. The lungs were clear to percussion and auscultation and a loud systolic murmur was heard over the precordium. Heart sounds were otherwise of good quality, rate, and rhythm. There was slight distention of the thick abdominal wall, marked tenderness and rigidity at McBurney's point, rebound tenderness referred to the same area, and hypoperistalsis. No masses were palpated. Pelvic and rectal examinations were not remarkable. The lumbar spine was rigid but no tenderness was elicited. Laboratory examinations showed the urinalysis to be negative and the leucocyte count to be 12,900.

The diagnosis of acute appendicitis was made and operation was performed through a McBurney incision. The appendix was easily identified and found to be grossly normal. A considerable amount of thin, bloody, serous fluid was present in the abdominal cavity. A small corpus luteum cyst of the right ovary was found to be bleeding. This was closed by fine silk sutures. On further exploration through a Weir extension, a portion of the omentum 4 by 8.5 cm. was found in the upper portion of the right lower abdominal quadrant. This omental mass was discolored by hemorrhage and early gangrene, which were the direct result of torsion of its narrow pedicle. The area of strangulated omentum was removed at the point of torsion and the resultant stump transected by a medium silk suture. The operative wound was then closed in layers without drainage, using fine black silk sutures.

Pathologic examination of the portion of strangulated omentum showed marked dilatation of the veins and capillaries with diffuse hemorrhage throughout the fatty tissue.

The postoperative course was entirely uneventful. The wound healed and she was discharged from the hospital on the eighth postoperative day.

Analysis—Our patients varied in age from 24 to 46 years. As reported by Morris,³ this lesion has occurred in patients between the ages of 30 and 50 years in the majority of instances. Men were most commonly affected, and the patient was usually described as robust or obese. Four of our patients were men and all were of robust or obese habit.

TABLE I

CASE NUMBER	AGE (YEARS)	SEX	RACE	OCCUPATION
1	29	Male	White	Unknown
2	40	Female	White	Housewife
3	24	Male	White	Waiter
4	30	Male	White	Hospital orderly
5	46	Male	Negro	Laborer
6	36	Female	White	Waitress

Hernia can be excluded as an etiologic factor in this series since the history, physical examination, and operation failed to reveal the existence of this condition. It is also unlikely that any previous acute inflammatory process contributed to the development of the omental torsion. Abdominal pain was the initial symptom of all of the cases beginning in the right lower quadrant in four, in the left lower quadrant in one, and throughout the abdomen in the sixth with radiation to and localization in the right lower quadrant later. It is perhaps of etiologic significance that the onset of the pain was usually associated with some strenuous activity, this observation having been made frequently in the past. In this connection Uzategui⁷ makes the rather curious statement that omental torsion is more frequent in acrobats than in any other persons.

The duration of symptoms was three or more days in four of our cases, the range being from one to four days. None of the patients appeared especially ill at the time of the initial examination, and it was a frequent observation that the general appearance and lack of prostration of these patients was not in keeping with the existence of an acute intra-abdominal process of several days' duration. Nausea or anorexia, but no vomiting, occurred in each patient. This phenomenon is not in accord with the usual sequence of events in acute appendicitis.

TABLE II

CASE NUMBER	DURATION OF SYMPTOMS (DAYS)	INITIAL SYMPTOM	DESCRIPTION OF PAIN			ASSOCIATED SYMPTOMS
			INTENSITY	INITIAL LOCATION	LOCALIZATION	
1	3	Pain	Moderate	Generalized	RLQ	Nausea, mild dysuria
2	4	Pain	Moderate	RLQ	RLQ	Anorexia
3	3	Pain	Moderate	LLQ	RLQ	Anorexia
4	1	Pain	Severe	RLQ	RLQ	Nausea
5	3	Pain	Moderate	RLQ	RLQ	Profuse diaphoresis, nausea
6	1	Pain	Moderate	RLQ	RLQ	Nausea, slight urinary frequency

The results of the physical and laboratory examinations revealed no distinguishing characteristics which indicated any diagnosis other than "acute appendicitis" The presence of fever, tenderness at McBurney's point, muscular rigidity in the right lower quadrant of the abdomen, rebound pain referred to McBurney's point, decreased intestinal peristaltic activity as determined by auscultation, and leucocytosis indicates the marked similarity of the clinical pictures of the two conditions In no instance was a mass felt on palpation of the abdomen or on rectal examination Tenderness in the cul-de-sac of Douglas was elicited in four of the six cases

TABLE III

CASE NUM BER	TEMP ERATURE (DEGREES F)	PULSE	TENDERNESS			RIGIDITY	RECTAL EX AMINATION	WHITE BLOOD COUNT	PREOPERATIVE DIAGNOSIS
			LOCATION	INTENSITY	REBOUND				
1	100 0	106	McBurney's point	Mild	Present	None	Tenderness on right	20,000	Acute appendi citis
2	99 4	88	McBurney's point	Moderate	Present	Moderate	Tenderness on right	10,200	Acute appendi citis
3	100 0	---	McBurney's point	Moderate	Present	-----	Tenderness on right	17,700	Acute appendi citis
4	99 4	116	R L Q	Severe	Present	Moderate	Negative	8,050	Acute appendi citis
5	99 6	80	McBurney's point	Moderate	Present	Moderate	Tenderness on right	7,050	Acute appendi citis
6	99 6	90	McBurney's point	Severe	Present	Severe	Negative	10,000 12,900	Acute appendi citis, possible tuberculous ileocolitis

A preoperative diagnosis of acute appendicitis was made in every instance, resulting in exploration of the abdomen through a McBurney incision in five of the cases and through a short transverse incision in the sixth The operative findings and procedures were significantly similar and, in fact, practically identical in all The presence of thin, sanguineous fluid in the general peritoneal or pelvic cavities of five patients led the respective surgeons to search further than the normal-appearing appendix for the responsible lesion This search extended first to the ileum and its mesentery and next to the pelvic viscera In one case a hemorrhagic corpus luteum of the right ovary was found, but was con-

TABLE IV

CASE NUMBER	INCISION	PERITONEAL FLUID	OPERATIVE PROCEDURE	RESULT
1	McBurney	Bloody	Excision of omental mass, appendectomy	Uneventful conva lescence
2	McBurney	Bloody	Excision of omental mass, appendectomy	Uneventful conva lescence
3	McBurney	Bloody	Excision of omental mass, appendectomy	Uneventful conva lescence
4	McBurney with Weir extension	Bloody	Excision of omental mass, appendectomy	Uneventful conva lescence
5	Transverse	None	Excision of omental mass, appendectomy	Uneventful conva lescence
6	McBurney with Weir extension	Bloody	Excision of omental mass, appendectomy	Uneventful conva lescence

sidered incapable of producing the amount of bloody fluid present in the peritoneal cavity. As a last resort, each surgeon, palpating the upper portions of the abdomen as well as possible through the limited incision, felt a mass in the right paracolic area or in the lower part of the right upper quadrant. The mass was grasped carefully with a forceps and gently delivered into the wound. Each lesion consisted of a small portion of the lower right border of the great omentum which had become twisted upon a narrow pedicle. The masses were all small, varying from 3 by 3 cm to 6 by 6 cm in size and showed evidence of thrombosis of the blood vessels with necrosis. In one case, the gangrenous omentum was loosely attached to the ascending colon by fresh, delicate fibrinous adhesions. The gangrenous portion was amputated and its pedicle ligated. In addition, appendectomy was done and the abdominal wound closed in layers without drainage. The postoperative courses of all of the patients were uneventful, and no complications developed subsequently.

DISCUSSION

There has been much speculation regarding the etiology of omental torsion. The association of torsion with hernia, omental tumor or cyst, and inflammatory or postoperative adhesions is more easily understood. However, these factors are absent in primary omental torsion, and the etiology is essentially unknown. A number of theories have been advanced and several of these are of interest. It is a common clinical observation³ that the right side of the omentum is the larger and the more mobile portion which hangs down into the right iliac fossa, while the lower left border usually lies higher in the left hypochondrium. The right side, therefore, would be more likely to be involved by exaggerations of the normal movements of the omentum. In practically all of the cases reported, torsion developed in the right inferior portion of the omentum.

Teller and Baskin¹ observed that torsion occurred more frequently in obese individuals. Infiltration with fat tends to increase the weight and length of the omentum and accessory projections usually found along its right border. The tendency to pedicle formation increases as the omentum becomes heavier and longer, thus predisposing to torsion.

Payr¹² pointed out that hemodynamic forces may be important in the etiology of omental torsion. Due to a change in the relative position of the omental mass, stasis in the tortuous veins may result in their distention and elongation in relation to the relatively straight arteries. This produces an unequal distribution of forces within the substance of the omentum favoring rotation about the more rigid arteries as an axis.

Sellheim¹² was of the opinion that rotary movements of the whole body, as in various forms of physical activity, transmitted to the viscera and particularly the omentum. In support of this theory is the observation that the onset of symptoms was associated with some vigorous physical activity.

It is obvious that no single theory adequately explains the production of torsion of the omentum in every instance and it is likely that many factors play a part often in the same case. This study has failed to reveal any definite cause for the omental torsion occurring in our cases. However, the observation that

all of the patients were moderately obese and that most were engaged in some rather vigorous activity lends support to the theories of Teller and Sellheim. Obesity and strenuous physical activity are probably important predisposing factors in the pathogenesis of omental torsion although the true cause is probably still unknown.

The diagnosis of torsion of the omentum has been made preoperatively in only a few instances in the past and in none of our cases. The clinical picture has been essentially indistinguishable from that of acute appendicitis except in those few cases in which a mass became palpable early in the course of the illness before abscess formation would be expected in appendicitis. Torsion of the omentum may be suspected when a person, usually a man in the third or fourth decade, is seized with rather sudden generalized abdominal pain which rapidly becomes localized in the right abdomen, usually the lower quadrant. The pain, usually mild at the onset, increases in severity. The progression of the symptoms, however, is usually less rapid than in appendicitis. Nausea or anorexia is present but vomiting is seldom a prominent feature. Only these ill-defined characteristics may suggest the presence of omental torsion rather than acute appendicitis, the laboratory and physical examinations usually revealing findings quite compatible with the latter diagnosis. It should be emphasized that no practical importance is attached to a preoperative diagnosis of omental torsion since both the nature of the lesion and the similarity of the signs and symptoms to those of acute appendicitis make surgical exploration of the abdomen mandatory.

At this clinic, operation for acute appendicitis is carried out through a McBurney incision, and it is of significance to note that it was unnecessary to make a second abdominal incision in order to palpate and deliver the omental mass although a Wen extension was made in two instances to facilitate the exploration. The location of the mass in the right portion of the omentum, usually just above the level of the incision, supports the opinion of Morris² that the right half of the omentum is longer and more subject to torsion.

While it is relatively unimportant to differentiate torsion of the omentum from other acute processes in the right iliac fossa preoperatively, it is essential that the surgeon be familiar with this entity and that he search for it when laparotomy fails to reveal one of the more common causes of acute abdominal pain or serosanguineous peritoneal fluid. Torsion of the omentum is strongly suggested by the presence of unexplained serosanguineous fluid in the abdominal cavity.

Excision of the involved portion of the omentum with careful ligation of the vessels in the pedicle is the treatment of choice for this condition. Bressan⁵ emphasized the importance of resection of the structure at a level above the involved tissue in order to prevent spread of thrombosis proximally to involve the vessels of the stomach and colon, but it seems to us that such a possibility is unlikely and of little practical importance.

The mortality resulting from torsion of the omentum is extremely low, only one death having been reported. The prognosis for a rapid, complete, and uneventful recovery is excellent.

SUMMARY

Six previously unreported cases of primary or idiopathic torsion of the omentum have been studied in an attempt to determine whether or not this lesion has any distinguishing clinical features which may be of diagnostic significance. A review of the literature reveals only sixty-four previously reported cases, and the present series of six brings the total to seventy. The theories pertaining to the etiology, the surgical significance, the treatment and the prognosis of this condition have been discussed and evaluated.

CONCLUSIONS

1 Idiopathic torsion of the omentum is a rare condition, to our knowledge only sixty-four previous cases having been reported in the literature.

2 Its cause is obscure, but adiposity and strenuous physical activity apparently are predisposing factors.

3 The condition is usually confused with acute appendicitis, but should be suspected in an obese or robust patient complaining of pain of several days' duration in the right lower quadrant of the abdomen, beginning during strenuous physical activity and being unassociated with vomiting.

4 The treatment of choice is excision of the gangrenous portion of the omentum with ligation of the vessels of its pedicle. The prognosis is excellent.

5 Primary torsion of the omentum should be looked for when laparotomy for acute appendicitis reveals a normal appendix and no other explanation of the clinical signs and symptoms, particularly the presence of sanguineous intra-peritoneal fluid. A careful search is usually necessary to demonstrate the lesion which is usually located in the right paracolic gutter or lower portion of the right upper quadrant of the abdomen.

REFERENCES

- 1 Teller, F, and Baskin, S J Torsion of the Omentum, *Am J Surg* 39 151, 1938
- 2 Eitel, C G A Rare Omentum Tumor, *Med Rec*, N Y 55 715 1899
- 3 Morris, J H Torsion of the Omentum, *Arch Surg* 24 40, 1932
- 4 Lipsett, P J Torsion of the Great Omentum, *Ann Surg* 114 1026, 1941
- 5 Mallory, T B Massachusetts General Hospital Case Records, New England J Med 226 237, 1942
- 6 Alecha, J M, and Lanza, R M Acute Torsion of Great Omentum Case, *Rev de Cir de Buenos Aires* 21 538, 1942
- 7 Uzategui, A Raffo Primary Intra abdominal Torsion of Great Omentum, *Rev med peruana* 14 632, 1942
- 8 Bressan, P G Free Torsion of the Great Omentum Case, *Bol San S5o Lucas* 5 35, 1943
- 9 Mainetti, J M, and Lopez, Ruf T Primary Torsion of the Great Omentum *Rev med d Hosp ital de La Plata* 1 101 1944
- 10 Novaes, C Carneiro de Primary Intra abdominal Torsion of the Great Omentum Case, *Rev brasil de cir* 13 481 1944
- 11 Anrus, DeW Primary Abdominal Torsion of the Entire Omentum *Univ Cincinnati Med Bull* 5 21, 1926
- 12 Hederstad, G C Intra abdominal Omental Torsion *Ann Surg* 109 57 1939

SIMULTANEOUS CHOLECYSTENTEROSTOMY AND CHOLEDOCHOENTEROSTOMY

EXPERIMENTAL STUDY*

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IN TWO patients subjected to one-stage pancreatoduodenectomy there was no obstruction to the common bile duct and, therefore, the latter was not dilated. In one instance the operation was performed because of invasion of the head of the pancreas by carcinoma of the pyloric portion of the stomach. In the other patient, a large carcinoma of the third portion of the duodenum invading the inferior margin of the head of the pancreas was resected. The problem of dealing with the normal-sized transected common duct was met by implantation of it into the first long loop of jejunum and a few centimeters

TABLE I. IMPLANTATION OF UPPER SEGMENT OF TRANSECTED COMMON BILE DUCT INTO GALL BLADDER

DOG	SURVIVED OPERATION	FINDINGS
869	59 days, killed	Abdomen negative, upper stump of choledochus obliterated in gall bladder wall
16	45 days, killed	Same as in Dog 869
9	61 days, killed	Abdomen negative, cholecystoduodenostomy functioning, common duct implanted into gall bladder patent

TABLE II. SIMULTANEOUS CHOLEDOCHODUODENOSTOMY AND CHOLECYSTODUODENOSTOMY

DOG	SURVIVED OPERATION	FINDINGS
606	32 days, peritonitis	Abscess at site of operation, cholecystoduodenostomy functioning, lower segment of choledochus obliterated
377	104 days, killed	Abdomen normal, patent cholecystoduodenostomy, patent choledochoduodenostomy
112	106 days, killed	Same as in Dog 377
604	111 days, killed	Same as in Dog 377
603	124 days, killed	Same as in Dog 377
3	124 days, killed	Same as in Dog 377
381	125 days, killed	Same as in Dog 377
542	126 days, killed	Abdomen negative, lower segment of choledochus obliterated, cholecystoduodenostomy functioning

distally a cholecystojejunostomy was performed. Simple ligation of the transected common duct does not appear to be the procedure of choice since experience has now revealed that in man, at least, the ligated common duct may open later with fatal bile peritonitis or development of a deep abscess even though a functioning cholecystojejunostomy is present. It must be admitted, however, that in these instances the common duct was enlarged.

The first patient alluded to previously was well eleven months after operation and has resumed his usual occupation, although recently a metastasis was excised from the lumbar muscles. The second patient succumbed three months

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after discharge and necropsy was not obtained, presumably death was due to recurrences

The question arises whether or not the implanted normal-sized common bile duct remains patent in the presence of a functioning cholecystojejunostomy. If cicatricial obliteration occurs, then implantation into the bowel would seem to be a needlessly complex procedure. It would appear that the transected normal-sized common duct could be implanted into the gall bladder by means of a small stab wound. This would obviate the presence of a free ligated common duct which might later open with escape of bile into the peritoneal cavity.

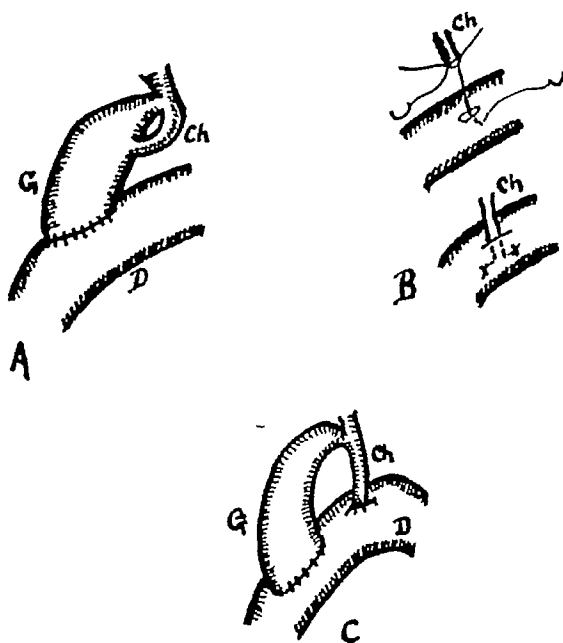


Fig 1—A, Showing cholecystoduodenostomy, G, gall bladder, D, duodenum, Ch, upper segment of transected common duct has been implanted into the gall bladder.
B, Showing method of implanting Ch, common duct into small bowel. Sutures are placed through edges of the duct and then passed through bowel wall and tied, one or two sutures are placed between serosa of bowel and serosa of common duct after the latter has been tied into the bowel.

C, Showing completed simultaneous cholecystoduodenostomy and choledochoduodenostomy.

This procedure was carried out in three dogs, and appeared feasible (Fig 1, A). In one, the stump of common duct turned into the gall bladder did not become obliterated but remained patent (see Table I).

Another series of animals was subjected to simultaneous choledochoduodenostomy and cholecystoduodenostomy to observe if subsequent cicatricial obliteration of the common duct would occur. The common duct was transected near the duodenum and the lower segment was ligated. The upper end of the transected common duct was then implanted into the second portion of duodenum. A small stab wound was made through the wall of the bowel and a silk suture inserted into each margin of the duct. The threads were brought through the duodenal wall from within outward on each side of the stab wound and tied. Interrupted sutures were placed between common duct and duodenal serosa (Fig 1, B and C). A cholecystoduodenostomy was performed just distal to the above anastomosis.

The results are summarized in Table II. In two instances the choledochus above the site of duodenal implantation cicatrized into a dense fibrous cord. In one instance (Dog 606) this may have been due to abscess formation at the site of operation. Necropsy revealed no gross evidence of biliary leakage. In six instances both choledochoanastomoses and cholecystoanastomoses remained patent and were apparently functioning.

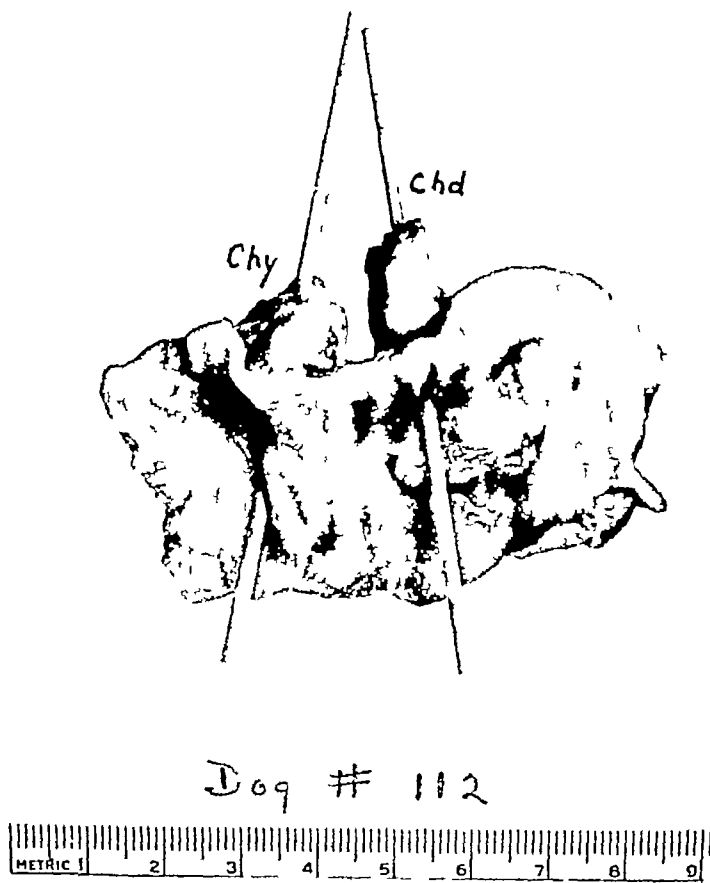


Fig. 2.—Photograph of specimen from Dog 112 (106 days) showing patency of *Chy*, cholecystoduodenostomy and *chd*, choledochooduodenostomy. Wooden probes are passed through each anastomosis.

SUMMARY

Simultaneous implantation of transected common duct and gall bladder into the duodenum was carried out in dogs. In six of eight animals both the cholecystoanastomoses and choledochoanastomoses remained patent. In two instances the implanted choledochus became obliterated by cicatrization. A method is thus suggested for dealing with the normal-sized common duct if pancreatoduodenectomy is performed in the absence of dilatation of the common duct (in which situation a choledochojejunostomy is performed). A satisfactory alternate procedure would appear to be implantation of the transected common duct into the gall bladder, the latter being utilized for cholecystojejunostomy. Simple ligation of the upper stump of common duct in pancreatoduodenectomy is to be avoided.

DISSECTING DIVERTICULITIS OF THE COLON

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WE WISH to call attention to a kind of diverticulum which heretofore has not been described. The usual forms represent an extrusion of a lumen through its retaining wall whereby the sacculation projects beyond the serosal surface of the bowel. In the dissecting (intramural) type a herniation of the lumen occurs into the wall of the gut and then this sacculation burrows its way along the wall. The analogy with dissecting aneurysm is apparent, although the mechanisms are not identical.

The basis for this report is furnished by a specimen removed from a 60-year old man who underwent a laparotomy with the preoperative diagnosis of obstruction in the descending colon due to carcinoma. The resected specimen comprised 16.5 cm of the sigmoid and was 6 cm in diameter. The serosal surface was deeply injected, and the appendices epiploicae were thickly edematous. On external palpation of the specimen the lumen was noted to be eccentric due to unequal thickness of the walls. On section, the thinner wall measured 1.5 cm, its layers appeared stratified, and were hypertrophic and edematous. The thicker portion of the wall measured 4 cm and was infiltrated with dense, white tissue. The mucosa was smooth, intact, and in places hemorrhagic, the mucosal folds were swollen and coarse. The initial line of incision to expose the lumen of the specimen fortuitously exposed a cavity in its thicker portion (Fig 1). Here the wall had become separated into two layers by a space which extended most of the length and part of the circumference of the specimen. A few centimeters from the oral end, a round mammilla-like stoma, 0.5 cm in diameter, was present which easily admitted a probe and communicated directly with the intramural sinus (Figs 1 and 2, A). This cleavage extended in the long axis of the specimen for a distance of 9 cm and was 2 to 3 cm in width. Approximately in its middle third, the cavity disclosed an accessory space extending laterally and in a circular manner around a portion of the wall. This lateral projection ran parallel to the transverse diameter of the specimen for a distance of 2.8 cm (Figs 1 and 3). At its distal end, the resected sigmoid revealed one larger and two smaller ordinary diverticula (Fig 2, B), one of which was separated from the intramural dissecting diverticulum by a thin septum.

Microscopically, the cavity space was lined with surfaces made up of chronic vascular granulation tissue which showed marked infiltration with polymorphonuclear leucocytes. An occasional remnant of mucosal glands was still present. The sinus space was situated outside of the circular layer of muscle.

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Fig 1—Resected specimen of sigmoid with a cloaca-like stoma (admitting the probe) and a portion of the lateral circumferential component of the intramural dissecting diverticulum

A



B

Fig 2—A, Oral end of the diverticulum opened B Aboral end of the specimen with three lesser diverticula and the major lesion

The inflammation extended into the adjacent adipose but was of mild character. At the apex of the main diverticulum other islands of mucosal glands were noted representing cross sections of the diverticula noted grossly (Fig 4).

Interpretation and Pathogenesis of the Clinical Course—The patient had a diverticulosis comparable to that which is quite common. One of these saccu-

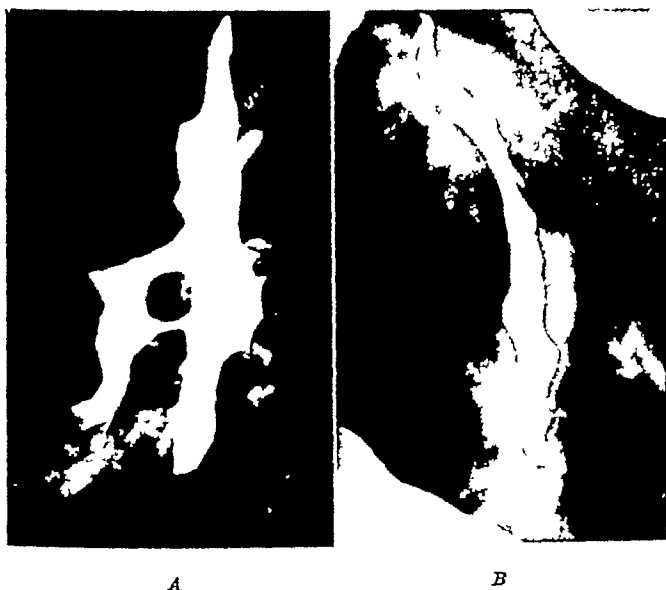


Fig 3.—The intramural diverticulum was filled with barium postoperatively and a roentgenogram taken to show the extent and ramifications of the lesion. (A) Anteroposterior and (B) lateral views.



Fig 4.—Microphotograph of histologic section illustrating luminal mucosa, an area of the intramural dissecting diverticulum, slight peridiverticulitis and three conventional diverticula.

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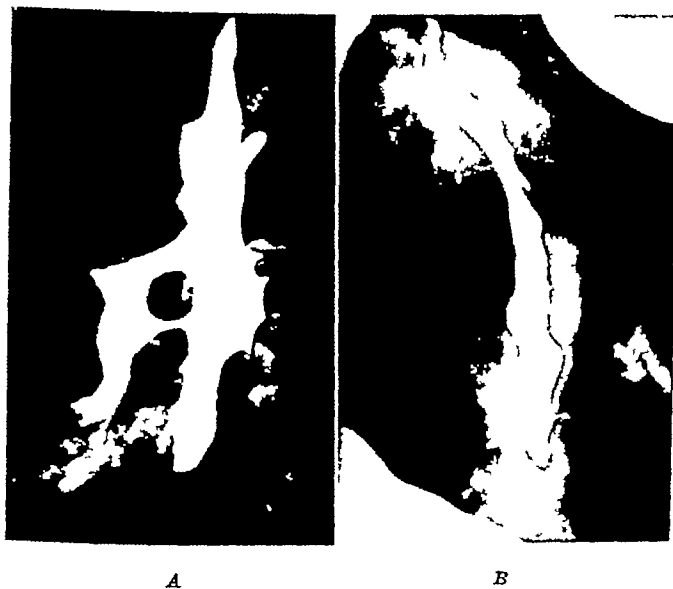


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lations, the most orally located, had its progression through the wall arrested, was turned distally, and then was propelled isoperistaltically within the wall of the bowel. Diverticulitis set in, which accelerated the dissection. The conver-

sion of the diverticulum into a chronic sinus aggravated the condition, facilitated its extension, and led to the formation of the lateral components. When this cavity became filled with feces and/or gas, the patient developed signs of obstruction. The degree of peridiverticulitis was not pronounced so that this feature was not appreciable in the onset of the ileus which caused admission to the hospital. At the time of the operation, little feces was encountered and the intramural diverticulum was ballooned out by gas under pressure. Its cloaca was edematous, therewith causing closure and a ball-valve or tension mechanism. Had the dissection gone further, with the diverticulitis burrowing into one of the distal diverticula, spontaneous healing might have occurred. In this event, the sigmoid would have shown a double-barrel configuration, the feces and gas being propelled down the accessory canal as easily as through the main lumen.

Thus, the sequence of events included sacculaton, intramural diverticulum, isoperistaltic propulsion, diverticulitis, dissecting diverticulitis, tension pneumo-diverticulum, and ileus.

CASE REPORT

The patient, D. B. (H6123), a 60-year-old white man, foreman lumberman, was admitted to the hospital because of abdominal distention, pain in the left lower quadrant, and vomiting of feceslike material. For ten days there had been no defecation. The patient came as a transfer from an adjacent community hospital where he had been treated twice with a Miller Abbott tube and enemas. The ailment was of fifteen years' duration, the initial symptoms including tympanitis, considerable flatus, borborygmi, and vague pains in the lower abdomen. These grouped themselves into bouts during which attacks he was unable to have bowel movements or expel gas. Enemas brought relief and he recalled that these episodes occurred approximately twice yearly.

One year prior to admission he suffered a bout of the same nature, which soon became rather painful and persisted. The stools were scanty, liquid, and water clear at first but then became tarlike and ribbon shaped. In the course of a few months he grew weak but knew of no weight loss. Shortly before admission the patient ceased to void by rectum, the abdomen became distended and hard, the pain was severe, nausea appeared, and he began to vomit material of fecal character. He was treated with the Miller Abbott tube, which relieved him, but the obstruction reappeared, did not respond to a second intubation, and thus transfer to this institution was necessary.

Physical examination revealed a muscular, well-nourished individual. Respiratory, cardiovascular, genitourinary, and neurologic systems were normal. Laboratory tests disclosed no abnormal values. A flat plate of the abdomen showed numerous loops of small bowel and the transverse colon distended by gas with little feces visible. A barium enema could introduce the contrast substance only up to the sigmoid. A definite irregularity of the mucosal pattern was noted in the mid sigmoid region and the roentgenologist thought he could identify diverticula.

The admission diagnosis included obstructive ileus due to pathology in the mid sigmoid, probably a neoplasm. On the eighth day of hospitalization exploration was carried out on the patient through a left, lower rectus incision. A large mass was found at the junction of the descending colon and sigmoid. The tumor could be mobilized only after some difficulty because of dense adhesions and diffuse fixation. After delivery through the incision, the morbid portion of the gut was resected and a double-barrel Mikulicz colostomy made. Three months thereafter, the closure of this colostomy was attempted but multiple fecal fistulas had developed. Six months after the initial laparotomy, a scar containing two draining sinuses and the loop of the bowel with the primary colostomy opening were dissected out, a third fistulous tract was found. All were excised and the original colostomy closed. Recovery was rapid and the man has been well during seventeen months of follow-up.

SUMMARY

1 A form of diverticulum of the colon is described which begins as a herniation of the lumen into the wall of the bowel. This sacculaton then burrows its way along the wall. The term dissecting (intramural) diverticulitis is being applied to this type.

2 The details of a case are given in which the sequence of events included sacculaton, intramural diverticulum, isoperistaltic propagation, diverticulitis, dissecting diverticulitis, tension pneumodiverticulum, and ileus.

THE ANATOMICAL HAZARDS OF LINGULECTOMY

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(From the Department of Anatomy, University of Minnesota)

IN A recent detailed analysis of variations in the left upper lobes of fifty lungs* certain striking departures from the usual patterns were noted in the lingular segments—those portions of the upper lobe most commonly resected for bronchiectasis

In most specimens the lingular bronchus is long and divides into the usual superior (B^4) and inferior (B^5) segmental bronchi† In 22 per cent, however, it divides early, and atypically, into an upper, posteriorly placed bronchus and a lower, anteriorly placed bronchus In about one-half of these (12 per cent) the upper stem is the posterior ramus B^4a , and the lower a combined B^4b and B^5 , but in the remaining 10 per cent the upper stem is an *accessory posterior bronchus* (BX^2a) which is supplying the interlobar side of the anterior segment (Fig 1) Accordingly, if the operator were to separate the lingular from the anterior segments in the usual plane (see arrow, Fig 1), he would cut across this accessory bronchus and associated artery and compromise the blood supply to what is usually the interlobar portion of the anterior segment

This accessory bronchus (occurring in 10 per cent of specimens) seems to represent an attempt of the lingular stem to take over that portion of the anterior segment in which the posterior ramus (B^2a) has failed to develop In the remaining 30 per cent of specimens in which B^2a has failed to develop, the territory is taken care of by a shifting of the posterior ramus of adjacent segments (either by ramus B^4a or B^3b , or both) An interesting consequence of this is that whenever B^2a is absent, the posterior vein (V^3), or part of it, changes its course and passes between the lingular and anterior segments instead of between the anterior and apical-posterior segments Therefore, in 40 per cent of specimens one should expect to find a big aberrant vein (VX^3) in the "avascular" plane between the lingular and anterior segments

A third point of practical importance is that in 22 per cent of specimens the lingular arteries arise from both anterior and posterior (interlobar) aspects of the lobe and in another 8 per cent they arise wholly from the anterior side In this position they are usually concealed by the branches of the superior pulmonary vein

Fourth, the artery to the interlobar surface of the anterior segment (A^2a or AX^2a) arises in conjunction with the lingular arteries in 38 per cent of specimens Thus, in resecting the lingular segments it is very easy to compromise the blood supply of the anterior segment

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†For terminology see SURGERY 18 706, 1945

Fifth, the inferior lingular segment drains into the inferior (instead of the superior) pulmonary vein in 10 per cent of specimens and in another 6 per cent receives tributaries from the lower lobe

Finally, among other variations, mention may be made of the occurrence of a trifurcate (instead of the usual bifurcate) pattern of bronchi in one-fourth of the specimens. This is due to the presence of an *accessory anterior bronchus* (BX^2b) which grows in between the anterior (B^2) and apical-posterior segments (B^{1+3}) and shifts the anterior segmental bronchus to a central position

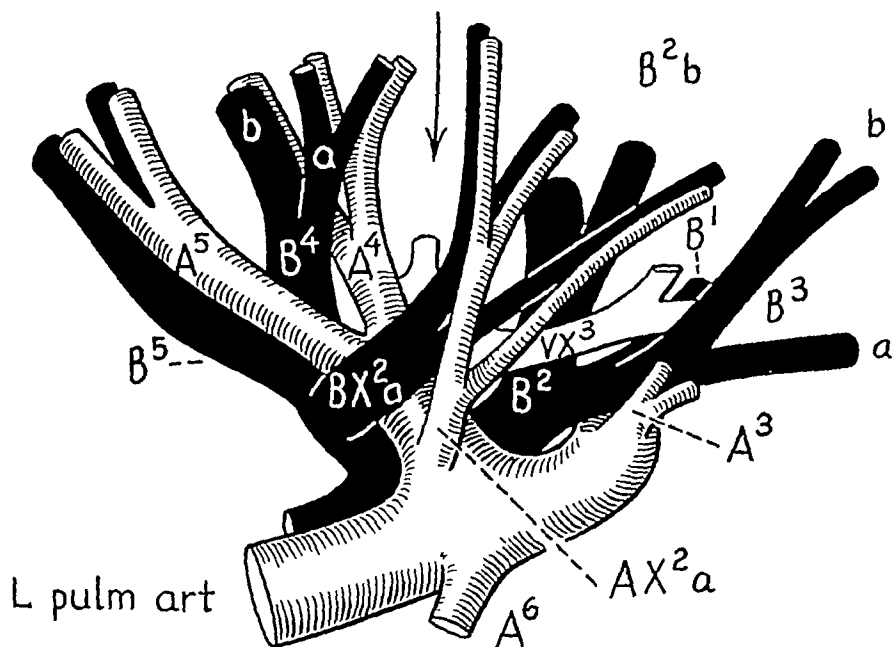


Fig 1—Diagram showing accessory posterior ramus (BX^2a) seen from interlobar aspect of left upper lobe. AX^2a , artery to accessory ramus. A^3 , posterior subsegmental artery. A^4 , superior lingular artery. A^5 , inferior lingular artery. B^4a and B^4b , posterior and anterior rami of superior lingular bronchus. B^5 , inferior lingular bronchus. VX^3 , aberrant course of posterior vein. B^2b , anterior and lateral rami of anterior segment. (The posterior ramus B^2a , is missing and is replaced by BX^2a , an aberrant outgrowth of the lingular stem). B^1 , apical bronchus. (After Boyden and Hartmann *Am J Anat.*, 1946)

As a consequence, ramus B^2a , which in lung abscess (Brock) is the most commonly involved of the left upper lobe bronchi, becomes a direct continuation of the upper lobe bronchus and thus is most favorably placed to receive aspirated material. Perhaps it is this shift in position which has rendered this bronchus so susceptible.

These and other variations are presented in numerous colored plates in the article cited (1946) and the terminology of the left upper lobe is brought into conformity with new observations.

A METHOD OF CRANIOPLASTY USING A READY-MADE TANTALUM CRANIOPROSTHESIS

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THE purpose of this paper is to describe a simple, easy, and quick method of repairing cranial defects from a basic, "ready-made," tantalum cranioprosthesis, to present the logic supporting the method, and to describe a technique of fabricating the basic prosthesis.

Briefly, a hemisphere of tantalum with a fixed radius is fabricated by hammering. This serves as an exemplar from which one or more cranioprostheses of any specifications may be cut and which is sterilized with the instruments for all craniotomies in anticipation of a possible need. All preliminary impressions, molds, models, or casts of cranial defects, or of the skull itself, or any intermediate preparatory craniotomies, are unnecessary and no special instruments, tools, or presses are required for shaping the metal.

LITERATURE

Adapted to the repair of cranial defects since the advent of World War II,³ tantalum has enjoyed extensive application and many procedures designed to enhance its actual manipulation have been reported. These are either based on conforming a cranioprosthesis according to an impression of a cranial defect, made indirectly through the scalp^{2, 7-9} at an intermediate craniotomy,^{8, 9} or, by shaping the prosthesis from the flat, sheet tantalum at the operating table.^{4, 6, 8}

We have found no reference to a ready-made method of tantalum cranioplasty. The possibility of forming a basic tantalum cranioprosthesis over a cast of the skull has been suggested very recently,⁹ however, and similar attempts to use the difficultly workable vitallium have been made.¹ It is also of passing interest that the South Sea Islanders of long ago unwittingly combined the advantages of a spheric surface in a ready-made cranioprosthesis when repairing cranial defects with coconut shell,¹⁰ although doubtless a matter of supply and not principle.

BASIC CONSIDERATIONS

Most of the calvarium is essentially little more than a composite of segments of four spheroidal surfaces centered around the four major prominences of the skull (Fig. 1). A series of measurements have demonstrated these to possess equal radii within negligible limits of difference. Experience has revealed these surfaces to constitute the only real problem in cranioprosthetics by any method as the intervening planispheric surfaces are easily duplicated, even at the operating table.

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The opinions or assertions contained herein are the private ones of the authors and are not to be construed as official or as reflecting the views of the Navy Department or the Naval Service at large.

The common radius of these major surfaces proved to be $2\frac{1}{4}$ inches in each instance. Admittedly, there is error in our mathematically undefined mensuration procedures, using modeling clay impressions or conformed tantalum strips and estimating their degrees of curvature, but this is certainly no greater than the slight individual variations and minor irregularities that normally exist in the conformation and contour of the skull. An equal error, or more, must exist when a cranioprosthesis is formed from an impression obtained at intermediate craniotomy. This error must increase when the impression is made indirectly through an abnormal and deformed scalp before the underlying bony defect has been either surveyed or treated.

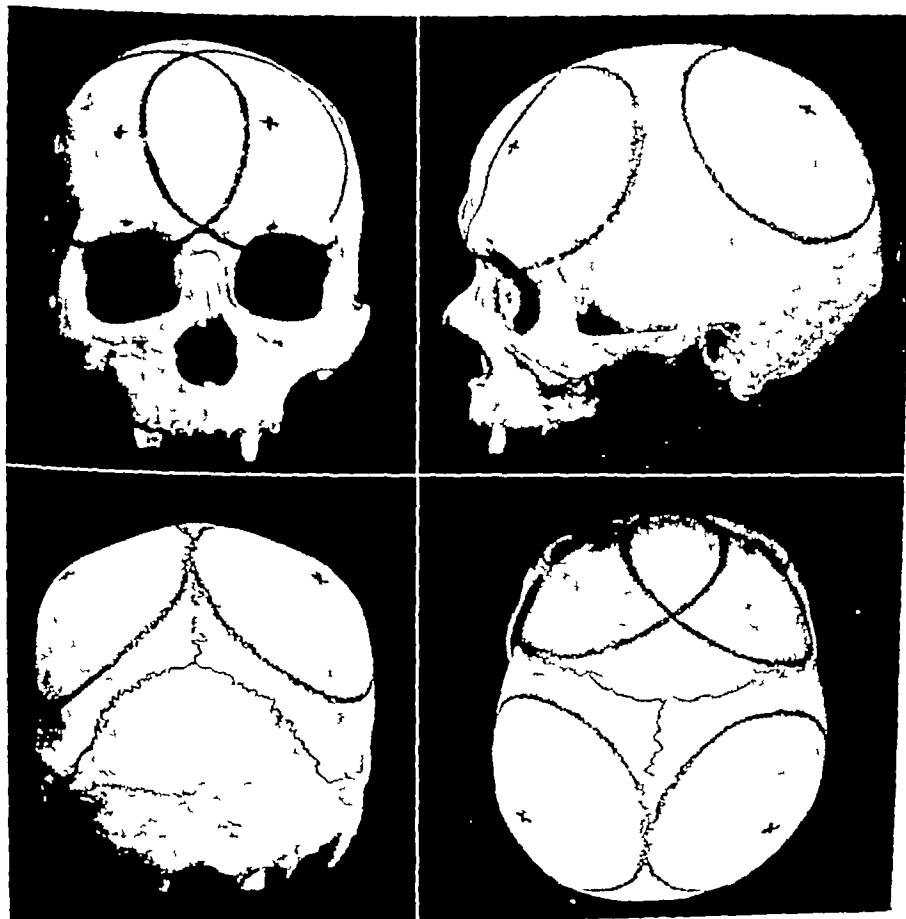


Fig 1—The four spheroidal segments of the calvarium all with equal radii

Were the skull transparent, it would not be at all difficult to visualize it as containing four spheres of equal radii, each centered on a perpendicular to the tangent of its surface through the central point of each major prominence. These points projected on a skull (Fig 1) aid in demonstrating the fundamental geometric premise on which we have proceeded.

This method of cranioprosthetics then is simply that of replacing one spheroidal surface by a basically identical one of different composition (tantalum

in this case. On the premise that these surfaces always have approximately the same curvature, a basic exemplar of equal radius is employed instead of resorting to various impressions, molds or casts. To demonstrate the validity of this premise, a half-segment of a basic tantalum cranioprosthesis was placed on a skull in various positions (Fig 2). A remarkable duplication of the natural skull conformation was evident without any alterations of the metal whatever.



Fig 2—Conformity of a half-segment of a basic tantalum cranioprosthesis variously positioned on a skull

The size of the cranial defect and its anatomic location need not adversely influence any intent to follow the method. Whether repairing a simple, comparatively flat temporal or parietal defect (Fig 3, *e, f, h*), or the more complicated frontal, frontoorbital, or hemicranial varieties (Fig 3, *a, b, c, d, g*, and *i*), the final prosthesis may be quickly fashioned from a basic, ready-made cranioprosthesis.

It must be understood that minor alterations may be necessary for an accurate duplication of a cranial defect, however, even in case of a defect in areas

of both greater and lesser curvature (Figs 3, *g* and 9, *a*), the natural flexibility of the shaped metal in the basic cranioprosthesis conforms nicely to the surrounding contour of the skull. Any variation from the basic cranioprosthesis will be slight and may be quickly and easily obtained at the operating table.

FABRICATION OF A BASIC CRANIOPROSTHESIS

Probably the most prominent physical property of tantalum is its malleability, being comparable to the unexcelled gold in this respect. And by

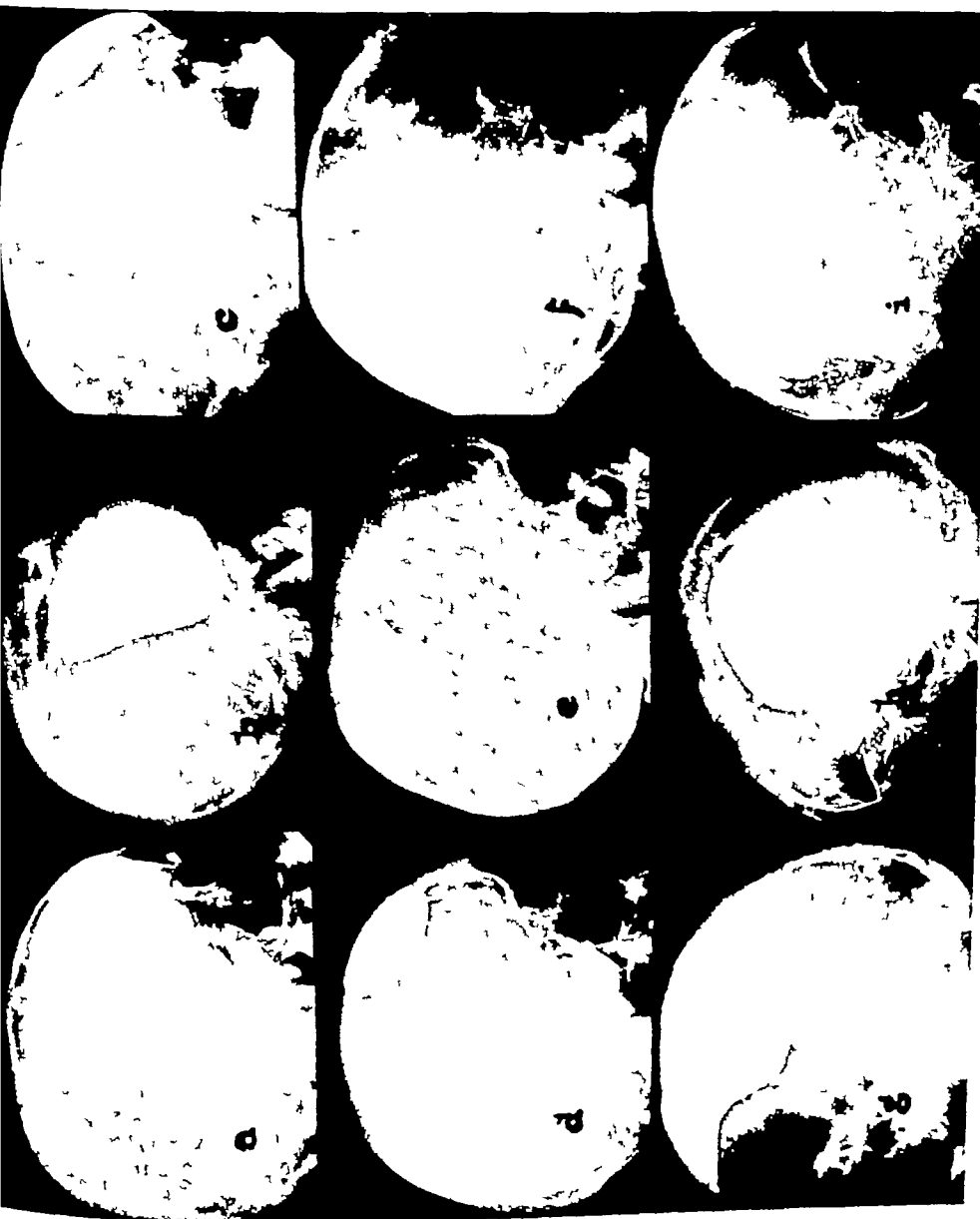


Fig 3—Postoperative roentgenograms *a*, *b*, *c*, fronto-orbital prostheses (Cases 16, 7 and 17) *d*, *e*, *f*, frontal and parietal prostheses (Cases 6, 13 and 20) *g*, *h*, *i*, frontoparietal cranial prostheses (Cases 14, 10 and 18)

virtue of the generic derivation of the adjective itself, "capable of being extended or shaped by beating with a hammer" (Webster), we have adopted this ancient artifice, the craft and skill of coppersmiths, silversmiths, and gold-beaters, in fabricating our basic tantalum cranioprostheses. The "hammering" has proved satisfactory and probably adds strength to the metal despite some slight thinning and an increase in surface area, whereas, pressing the tantalum may well create stresses and strains, as well as furrows and kinks¹⁰

No special tools or equipment are necessary, although certain conveniences do facilitate the fabrication. Any hammer of the ball-peen type and an anvil of some sort suffice. Working the metal on soft lead spares it much abuse and for this reason we use a rounded, lead-filled, orthopedic mallet and a shortened, lead-filled, shell case with a cupped surface (Fig 4).

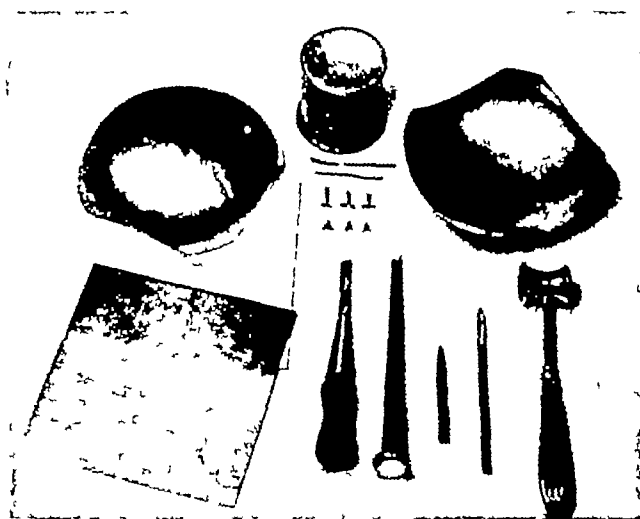


Fig 4—Two basic prostheses, anvil, rabbeting chisels, lead mallet, anchoring devices, and punches.

The actual shaping of the metal is best begun by placing the center of a 6 by 6 inch, tantalum cranial plate (the 0.015 inch plate used in our cases) over the cup in the anvil (Fig 5, a). The hammering is best executed by circular, tangential blows to avoid creasing the metal or breaking its surface. Work-hardening is obviated by avoiding any staccato, ditto blows on the same point of impact. The hammering should always proceed from the center of the plate outward and as the tantalum begins to take shape it will be found that it does so more readily if the corners of the plate are removed. Within five to ten minutes, the plate becomes saucer-shaped (Fig 5, b) and in about thirty minutes, the desired basic hemisphere is completed (Fig 5, c). A protractor, or cardboard hemicycle, with a $2\frac{1}{4}$ inch radius is used as a guide to the proper curvature. To eliminate the time and actual manual labor involved, it does not seem amiss to hope that such basic tantalum cranioprostheses might be supplied as prefabricated, stock items, ready-made for use, should this method of cranio-plasty find favor.

No additional treatment of the metal is necessary or advisable. Some operators prefer to perforate the prostheses with punch or drill,⁴ a practice seldom followed by us. One possible refinement, that of roughening the surface of the tantalum with a rasp to elevate small burrs of metal (Figs 6, *g* and 9, *b*



Fig. 5.—Fabrication of a basic tantalum cranioprosthesis. *a* Hammering. *b* gun with metal over center of anvil. *b* shaping of a prosthesis half completed. *c* finishing touches to a completed prosthesis.

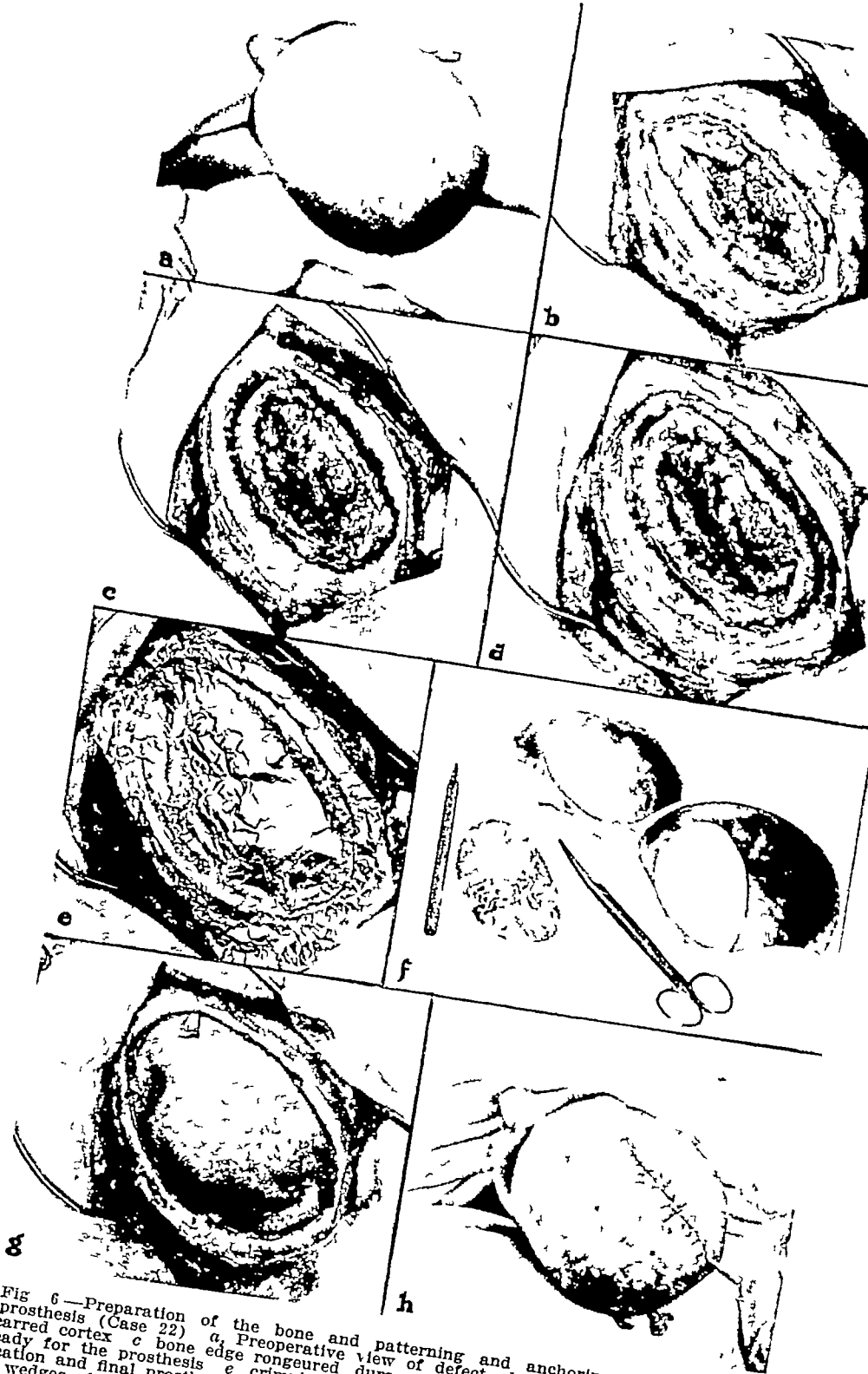


Fig 6—Preparation of the bone and patterning and anchoring an inlay tantalum cranio prosthesis (Case 22) *a*, Preoperative view of defect *b*, untreated bone *c*, bone edge rongeured *d*, bone edge rabbeted *e*, crimping the lead foil template along the rabbit *f*, pencil demarcation and final prosthesis cut-out *g*, completed inlay anchored into position with four barbed wedges of tantalum *h*, wound sutured with figure-of-eight, nylon No 3 over a superficial Penrose drain

and c), or pitting the surface with a machinist's punch (Fig 9, d), has not proved of sufficient value to warrant the time and effort expended. This idea was born of pure desperation in the hope that granulations would somehow creep across this bed in those several cases where there was insufficient scalp for closure after the ravages of bullets and débridement, and when plastic procedures were not immediately feasible.

After fabrication of a basic cranioprosthesis, there is a certain amount of metallic lead adhering to its surface from the mallet and the anvil. To remove this, each prosthesis is scrubbed in warm soapy water, with a brush and steel-wool before sterilization with the craniotomy instruments. Any adhering lead particles acquired from whatever hammering is done at the operating table can be removed by merely wiping with a wet sponge.

FABRICATION OF A FINAL CRANIOPROSTHESIS

At operation, the cranial defect is first prepared and then patterned by digitally crimping a sheet of lead foil (obtained from the waterproof wrappings of overseas cartons) along the bone edges, using care to allow for the curvature of the skull to insure a foil template of accurate dimensions (Fig 6, e). This template is then placed on a ready-made cranioprosthesis in the most advantageous position and outlined with a sterile pencil (Fig 6, f). This demarcated portion is now cut out with curved scissors as straight cutters tend to obliterate the curvature of the shaped metal (curved dissecting scissors suffice very well). If an onlay cranioprosthesis is contemplated, the tantalum is to be cut out a few millimeters beyond the pencil marking. If an inlay prosthesis is desired, the crimping will have been done along the shoulder of a formed rabbet (Fig 6, d and e) and so will fit the defect exactly.

As this cut-out portion is fitted into position (Fig 6, g), minor alterations may be indicated. Any unusual or accessory bends or angles, such as in the frontotemporal-orbital areas (Fig 9, c and d), can be quickly fashioned with the same mallet and anvil that fabricated the basic cranioprosthesis and which are routinely sterilized with the craniotomy instruments also. Crinkling of the margins does not occur so that notching, folding, or serrating the edges of the tantalum is unnecessary to produce an exact fit. Once the bony defect is prepared, it requires but five to ten minutes to fashion even a complicated cranioprosthesis.

PREPARATION OF THE BONY DEFECT

The preparation of the bone for insertion of a tantalum cranioprosthesis necessarily differs with the varying situations presented. An extensive, shattering, or excavating type of skull fracture (Fig 3, g and i) is not uncommon in combat head wounds and permits of very little bony architecturing due to the insecure, oft-subcondylated bone fragments bounding the actual cranial defect. In such cases, the tantalum is best fitted as an onlay type of prosthesis (Fig 9, b and c) which overlaps the bone edges by a few millimeters.

The average case is less of a problem and in these an inlay type of prosthesis (Figs 6, g and 9, d) is preferable, especially when the cranial defect is located

where the scalp is naturally thin, when there is insufficient scalp for closure, or when in a prominent position. This type of cranioprosthesis has also proved to be particularly advantageous in those cases where a cortical scar has been resected, a fungus cerebri has existed, or a cerebrospinal fluid fistula is present.

In all cases, the edges of the bony defect are rongeured away until viable bone is encountered, irrespective of whether the wound is fresh or some weeks or months old (Fig 6, *a*, *b*, and *c*). When using an onlay type of cranioprosthesis, no additional treatment of the bone is either necessary or advisable.



Fig 7—A method of rabbeting the bone edge using a right-angle rabbeting chisel

An inlay cranioprosthesis is made possible by the tabulation of the skull. The freshly rongeured bone edge is rabbeted down through the outer table and diploe to the harder inner (vitreous) table (Fig 7). This forms a rabbet, or rout, with an approximate one-fourth inch shoulder, for the support of the prosthesis (Fig 6, *d*). This procedure may be done with an ordinary flat bone chisel and mallet, or, a Stout No 3 dental chisel.⁹ The attendant jarring is considerable and objectionable, however, to diminish this, we made a one-fourth inch rabbeting chisel from a common one-half inch, flat, carpenter's chisel (Figs 4 and 8). This markedly reduced the trauma and conserved time, since the rabbet is formed in but one excursion of the chisel around the edge of the bony defect. This first instrument was later improved to obtain a better cutting edge and gain a little streamlining, culminating in the tool steel rabbeting chisel now in use (Fig 8).

ANCHORING A COMPLETED CRANIOPROSTHESIS

Although high in the electrochemical series, use of dissimilar metals is to be avoided, and only tantalum fittings should anchor a tantalum cranio-

prosthesis. Vitallium screws have, however, apparently been successfully used with tantalum⁷ for this purpose. Before securing a prosthesis, we even remove superficially placed silver hemostatic clips when present from an operation performed elsewhere. Tantalum hemostatic clips are not objectionable, of course.

The only other admonition is that cranioprostheses which are insecurely fixed to the bone interfere with the formation of the characteristic membranous envelope around the tantalum. Also, even slight mobility disturbs healing and may actually erode the overlying soft tissues.

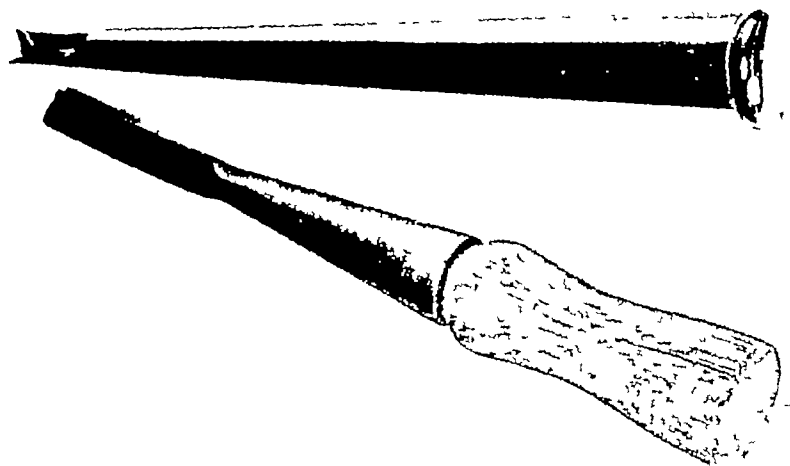


Fig. 8.—Rabbeting chisels: the new and the old.

As noted earlier, an onlay cranioprosthesis frequently constitutes somewhat of a problem in bone preparation due to the insecurity of the fragments, and the same problem obtains regarding its fixation. Tantalum screws are probably the ideal fittings, and, while they have not been available to us, they can be satisfactorily homemade.⁴ There are several alternate methods of fixation, such as ordinary suture materials, tantalum wire, tantalum ribbons (cut from scrap and used like wire) and tantalum cotter pin, or, paper fastener-shaped devices (also fashioned from scrap). Tantalum wire was used in two cases by one of us (H. J. M.), with some difficulty in binding the prosthesis down tightly to the bone. The ribbon, used because wire was not available, does not have this objection but it does leave an undesirable elevation in the scalp (Figs 3, *g* and 9, *a* and *c*). The cotter pins, proved satisfactory in the one instance they were used (Figs 3, *c* and 9, *b*), are inserted from the dural aspect of the bone, points upward, through matched holes drilled in the bone and the prosthesis.

An inlay prosthesis may be cut to size and shape so very accurately that it need be sprung slightly to fit into its bed.^{9, 10} We have elected to secure the prostheses in our cases with glazierlike wedges, points, or triangles, lest they become dislodged. This is not an original practice,^{2, 4, 9, 10} but a useful refinement is to barb, or feather, the entering margins of these wedges toward their base, offsetting alternate barbs slightly, like saw blade teeth (Fig 6, *a*). Once

in position they are very difficult to remove. Again, it does not seem amiss to suggest that these devices might also well be supplied as stock items ready for use.

The driving-in of the wedges without buckling them or chipping the bone is facilitated by first punching a small flattened opening into the outer table, or diploe. A short, flat punch devised from a screw driver serves the purpose, a similar punch made from a discarded dental chisel serves equally well but does



Fig. 9.—Various types of cranioprostheses anchored in place. a Combination onlay-inlay prosthesis (see Fig. 3 g). b Onlay prosthesis, rough surface (see Fig. 3 c). c Combination onlay-inlay prosthesis (see Fig. 3 a). d Inlay prosthesis, grater surface (see Fig. 10 b and c).

not tolerate much punishment (Fig 4) With this initial precaution it has not been necessary to fashion the wedges from a heavier gauge tantalum¹⁰

An inlay prosthesis may also be secured with tantalum wire¹⁰ which passes through matched holes drilled in the metal and one, or both, tables of the skull Occasionally, it is necessary to resort to a combination onlay-inlay cranio-prosthesis with appropriate anchoring devices (Fig 9 a and c) Temporal prostheses are often difficult of fixation due to the extreme thinness of the bone Cutting notches and offsets in the edges of the metal and riding these on the bone edge, in clothespin fashion serves satisfactorily

Other but less practical anchorings have been tried and abandoned The most promising of these was that of retaining several pointed flukes on the edges of a completed prosthesis and attempting to fit these into corresponding slots punched into the outer table or diploe Tantalum is far too ductile a metal, however, to allow much manipulation of this kind Occasionally, one or two flukes may be retained and fitted into appropriate notches in the outer table to obviate any displacement when the wedges are not sufficient in themselves

Irrespective of the type of cranioprosthesis employed, it is covered with the periosteum, if there is any remaining, before the scalp is sutured Any preference of scalp suture is satisfactory We have utilized but a single layer of interrupted, through-and-through, figure-of-eight, cotton or nylon sutures in the majority of our cases These are widely spaced to maintain the maximum blood supply Closure is rapid and prompt healing follows When suturing below the hairline, however, a single row of inverted, interrupted cotton sutures in the galea leaves a less obvious scar A dependent Penrose drain may be indicated for twenty-four to forty-eight hours, depending on the amount of oozing, and not infrequently we found it imperative also to place a hemostatic gauze pack in the absence of either an electrocoagulator, hemostatic clips, or fibrin foam

The usual head dressing consists of two elastic bandages tightly applied over an abundance of well-fluffed, gauze sponges Unless a drain must be removed, this initial dressing is not molested for the first five days Fluid collections under the scalp have not been a problem and aspiration was necessary in but three cases, on one occasion in two cases, and on three occasions in the other case

MATERIAL

This method of employing ready-made, tantalum cranioprostheses for the repair of cranial defects has been used by us in a series of twenty-five cases since September, 1943, all involving service personnel The majority have been operated upon since May, 1945, however, pursuant to the bloods Two Jima and Okinawa Campaigns

Of the total, seventeen were compound, comminuted, depressed fractures sustained in combat, seven were injuries of a similar nature but received in some other manner, and, one was a defect remaining after removal of an osteoma and adsorption of a rib graft performed elsewhere All but four cases had associated penetrating wounds or lacerations of the brain and nineteen had dual defects

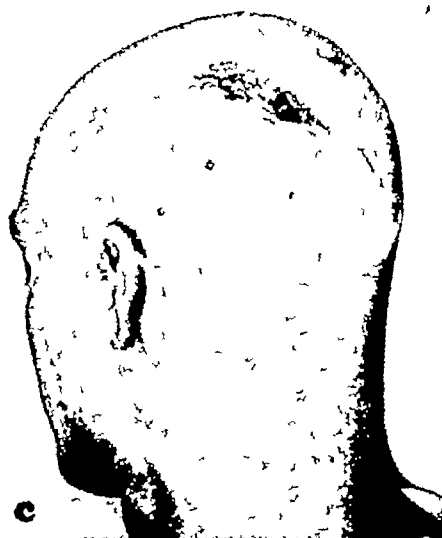
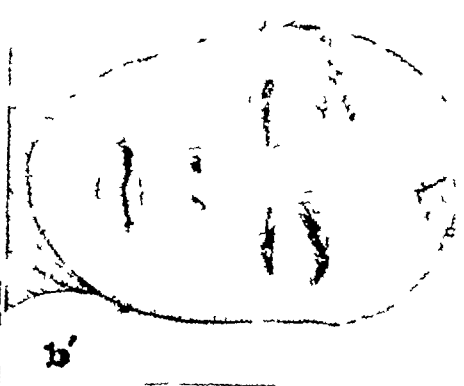
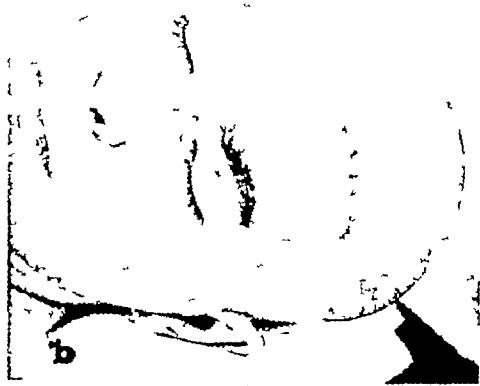


Fig 10—Preoperative and postoperative photographs demonstrating wounds defects and closures *a* and *a'* Fungus cerebri and cerebrospinal fluid fistula pedicle scalp flap placed over prosthesis (Case 7 see Fig 3 *b* and *b'* Operative views of case similar to Case 7 (Case 24 see Fig 9 *d*) *c* and *c'* Posterior parietal defect (Case 9)

underlying the tantalum. There were three fatalities in the series, not in any way attributable to either the cranioplasty or the presence of the tantalum cranioprosthesis.

The anatomic distribution included every region of the calvarium with two frontal, two frontoorbital, four frontotemporal, two temporal, two vertex, seven parietal, one occipital, and five hemicranial defects.

In nine of the cases, brain, skull, and scalp alike all constituted one large open wound and in five other cases we were confronted with thick, extensively scarred, and distorted scalp overlying tremendously misshapen, comminuted, and depressed bony defects. Of the total of fourteen cases so complicated, in eight the scalp and periosteum were so severely lacerated, contused, and/or debrided as almost to preclude primary closure, with a total absence of these tissues in the region of the defect in one-half of them. Pedicle scalp flaps were necessary in eight of the fourteen cases, the presence of other scalp lacerations often making this difficult and even dubious on occasion. In five of these, and one additional case, there was a loss of temporal muscle which was particularly deforming (Figs 9, c and d and 10, a, a', b, and b')

Case reports have been intentionally omitted from this discussion in deference to a second paper now under preparation, on the entire series of cases. We have used some of the photographs and roentgenograms of a few of these to illustrate the points we wish to emphasize.

RESULTS

The results were considered to be technically and esthetically satisfactory in all twenty-five cases, of which there were five onlay, eighteen inlay, and two combination onlay-inlay types of cranioprostheses. At this writing, we are satisfied with the method but not to the exclusion of anticipating improvements or better methods. Until indications appear to the contrary, we shall continue to employ the techniques described. In general, this group of cases presented problems not ordinarily encountered in cranioplasty. Some of the combat wounds aroused despair for life itself, without regard to esthetics or the procedures to gain it best.

The greatest single obstacle to complete cosmetic success was the distressing loss of soft tissue and its blood supply by explosives, missiles, scalpel, or other means. We have not been fortunate in the use of pedicle scalp flaps in these particular cases, a procedure that is deforming in itself, which suggests the use of grafts from another part of the body. A successful case of this kind has been reported just recently.⁵ While we have failed to cover completely an underlying tantalum cranioprosthesis in several instances, the naked area has at least been reduced to a size consistent with grafting, in a rear area hospital. The patients have enjoyed the distinct advantages of the cranial repair meanwhile (Fig 10, a, a', b, and b'). In those patients sustaining loss of temporal muscle, it seems advisable to be content with an initial accurate cranioprosthesis. Any residual deficit that is detrimental or disturbing to the patient can await later correcting, plastic procedures.

It is quite likely that methyl methacrylate will supplant tantalum as a cranioplastic material. Definite possibilities of greater ease in correcting tissue losses are suggested by the lighter weight of the substance and the fact that it welds readily. We are attempting to adapt plexiglas (methyl methacrylate) to this method of cranioprosthetics described for tantalum, at the present time.

CONCLUSIONS

- 1 The logic, fabrication, and method of using a hemispheric, ready-made tantalum cranioprosthesis is described.
- 2 The technique of patterning onlay and inlay types of cranioprostheses is detailed and various anchoring devices are discussed.
- 3 A new rabbeting chisel is described.
- 4 The major virtues of the method are
 - (a) A ready-made tantalum cranioprosthesis is available at all cranial operations.
 - (b) All impression materials and processes, and any intermediate preparatory craniotomies, are eliminated.
 - (c) Anatomically symmetrical and accurate cranioprostheses are provided without delay or difficulty.
 - (d) It is readily available to military surgeons, in general, and appears applicable to the traumatic and industrial neurosurgical counterparts in civil practice, as well as the customary cranioplastic demands.
- 5 A total of twenty-five cranial defects have been repaired by this method, with technically satisfactory and esthetically acceptable results in all.

REFERENCES

- 1 Beck, C. S. Repair of Defects of Skull by Ready made Vitalium Plates, *J. A. M. A.* 118: 798-799, 1942.
- 2 Echols, D. H., and Colclough, J. A. Cranioplasty With Tantalum Plate, *SURGERY* 17: 304-314, 1945.
- 3 Fulcher, O. H. Tantalum as Metallic Implant to Repair Cranial Defects. A Preliminary Report, *J. A. M. A.* 121: 931-933, 1943.
- 4 Gardner, W. J. Closure of Defects of the Skull With Tantalum, *Surg., Gynec. & Obst.* 80: 303-312, 1945.
- 5 Harris, M. H., and Woodhall, B. Plastic Closure of Skull Defect, *SURGERY* 17: 422-428, 1945.
- 6 Hemburger, A. J., Whitcomb, B. B., and Woodhall, B. The Technique of Tantalum Plating of Skull Defects, *J. Neurosurg.* 2: 21-25, 1945.
- 7 Kazanjian, V. H., and Holmes, E. M. Reconstruction After Radical Operation for Osteomyelitis of the Frontal Bone, *Surg., Gynec. & Obst.* 79: 397-411, 1944.
- 8 Mayfield, F. H., and Levitch, L. A. Repair of Cranial Defects With Tantalum, *Am. J. Surg.* 67: 319-332, 1945.
- 9 Robertson, R. C. L. Repair of Cranial Defects With Tantalum, *J. Neurosurg.* 1: 227-236, 1944.
- 10 Woodhall, B., and Spurling, R. G. Tantalum Cranioplasty for War Wounds of the Skull, *Ann. Surg.* 121: 649-671, 1945.
- 11 Woolf, J. I., and Walker, A. E. Cranioplasty. Collective Review, *Surg., Gynec. & Obst.* 81: 1-23 (*Internat. Abst. Surg.*), 1945.

Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M D

NASAL DEFORMITIES AND THEIR REPAIR

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THE esthetic importance of the nose is great because of its prominence on the face. Since the sequelae of injury or disease are so disfiguring, and congenital or developmental abnormalities so frequent, the plastic surgeon is repeatedly called upon to reconstruct the nose or to improve the appearance of the part that remains. To many physicians, however, the nose may be a rather uninteresting part of the body, unless there is some nasal obstruction or impairment of breathing, but to the individual, an external deformity of the nose may be the primary object of his concern, though no obstruction exists, and this, regardless of whether the deformity is congenital or the sequelae of injury or disease. In the business or social world, the person with an unsightly nasal abnormality may be seriously handicapped and consequently develop somatic and psychic disturbances attributable to its presence. In many instances these visible and conspicuous nonconformities are more harassing than congenital or acquired defects in other parts of the body. It is true that many individuals quite readily compensate for physical or physiologic impairments, but in the case of facial disfigurement, there is no mechanism that will shield a defensive individual from a continued attack upon his self-esteem. The person who is unhappy because of an unsightly nose or protruding ears will find his inner security assailed each time he looks into a mirror. These unfortunates, children or adults, should, therefore, be given an opportunity to have this barrier removed, even though life is not endangered by the affliction, and they should not be encouraged to endure the misery and abuse to which they are predestined, for no one knows the indelible mental effects produced on the afflicted, and, at least in some instances, ridicule and contempt are a direct sequence of the deformity. The need for reconstructive plastic surgery for the correction of the condition and the elimination of the handicap and the possible mental sequelae is, therefore, evident. It should not be construed, however, that every individual with a nasal abnormality should be operated upon, for there is no proportional relationship between the size or severity of the physical defect and the reaction to it. Individuals with only slight or seemingly minor facial abnormalities frequently suffer more mental distress than those whose defects are pronounced. This mental distress which stems not from physical factors but from psychologic ones is as real as actual physical pain and demands tolerant and understanding consideration.

Psychiatric Diagnosis—The plastic surgeon must distinguish between the patient whose anxiety is based upon factors other than the presenting complaint and the patient suffering from a situational reaction. If a surgeon, consulted by a patient whose psychologic state may be a reflection of the deformity, is uncertain as to the nature of the reaction or anxiety, he should have no more hesitation in requesting an interview with a psychiatrist than in asking for a medical or ophthalmologic consultation, or a roentgen examination. The psychiatrist will be able to help differentiate those patients whose reaction is related to the disfigurement and in whom a repair or improvement of the abnormality will be helpful from those with a psychiatric condition in whom repair will result only in the production of another symptom for the expression of emotional difficulties. The psychologic result of the operation in these two types of cases will be entirely different. In one instance, a helpful service will have been performed, in the other, a great wrong may have been committed. In this respect, the remarks of Blair and Brown¹ are pertinent. "As a general working rule, the more pronounced the deformity or loss, the more likely is a reasonably good result to be acceptable, but, conversely, it is well to be cautious about embarking upon the correction of slight defects. A patient's inability to state accurately and succinctly the particular thing that displeases him should excite grave self-doubt in the surgeon's own ability to satisfy. The same uncertainty should also excite the suspicion that the accused nose might not be the real fault." In this same thought Gillies² remarked, "The size of the hump of a nose bears little relation to the misery of the patient and to the wisdom of advising its removal. Even in ordinary life a nasal defect may produce such an inferiority complex as genuinely to hinder the patient's happiness and pleasure. There is a well-known class, however, which has a nasal complex not relieved by operation, however successful, and such patients are to be avoided. But the differential diagnosis between the genuine and the false is one of considerable difficulty. The help of the psychologist is of great value when there is any doubt."

ANATOMIC ASPECTS OF NASAL DEFORMITIES

Bone-Cartilag Framework—The two *nasal bones* articulate with each other in tent fashion to form the bridge of the nose anteriorly, and with the nasal process of the maxilla laterally. Above they are narrow and strong and supported by the bony septum. Below they become thinner and wider, and this relative weakness, as well as their exposed position, accounts for the prevalence of fractures in this location (Fig 1).

The *septal cartilage* gives structural support and contour to the lower half of the bridge of the nose and forms the greater part of the median partition. Anteriorly it becomes continuous with the upper lateral cartilages. The septal cartilage is involved in almost every nasal disfigurement. Being a flexible body, it yields easily to pressure and may be dislocated from any or all of its attachments. If it is dislodged or bent, or for any reason it fails to exercise its function of support, the surrounding structures then also become a part of

the displacement. In the developmental stage, extending through puberty, the septal cartilage, through vertical upward pressure by the vomer below it, raises the dorsum of the nose (Fig 1). This explains the failure of the forward extension of the nose in disease or injury to the vomer occurring before puberty. Spurs on the septum may have to be removed prior to rhinoplasty since the narrowed nasal arch may impinge upon them and cause obstruction. Associated with a long nose is an overhanging septum, and for its correction a wedge of the septum and mucous membrane is removed (Fig 2). Should this deformity be associated with a protruding upper lip, it can readily be corrected by removing the nasal spine and readjusting the nasolabial angle after the method of Aufricht^{3, 10}

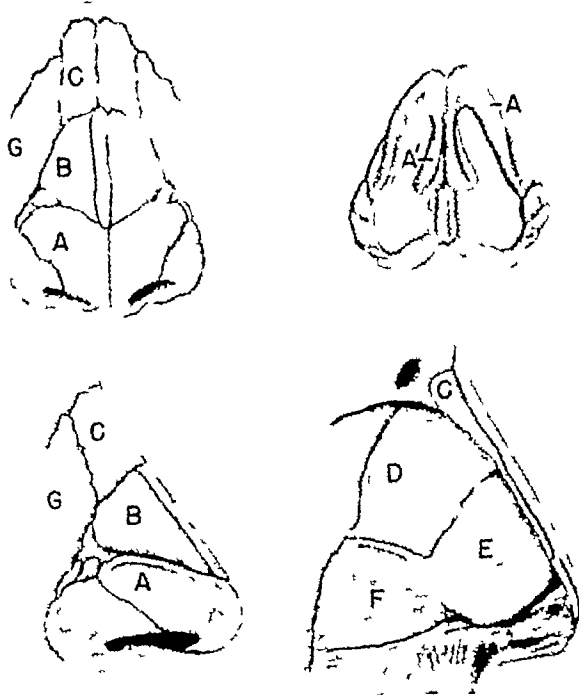


Fig 1—Bone and cartilaginous framework of the nose. The lower part of the nasal framework is cartilaginous the upper part consists of bone. The nasal bony arch consists not only of the nasal bones (C) but also the nasal process of the superior maxilla (G). The lower lateral cartilage the alar cartilage, is horseshoe shaped consisting of a lateral crus (A) which aids in the formation of the ala and a median crus (A') which with the medial crus of the opposite side supplies the structural support for the columella. The cartilaginous septum (E) forms the greater part of the median partition. Anteriorly the septal cartilage becomes continuous with the upper lateral cartilage (B), the triangular cartilages which diverge from it in a winglike manner. The osseous septum comprises the perpendicular plate of the ethmoid (D), the vomer (F) and the frontal spine of the nasal bone.

The anterior extremity of the vomer abuts on the incisive crest of the maxillae and is of much surgical importance, because it is here that the lower segment of the septal cartilage which supports the tip of the nose is inserted. In submucous operations in which the thickened vomer is widely resected, and especially when the adjacent nasal spine has been sacrificed, there is likelihood of a sinking of the dorsum and a consequent lowering of the tip of the nose (Fig 3).



Fig 2—A long hump nose with an associated overhanging septum is corrected by first removing the hump to lower the nasal bridge line followed by the removal of a wedge from the anterior border of the septum together with the redundant mucous membrane thereby elevating the tip and reducing the entire size of the nasal pyramid



Fig 3—In submucous operations in which the septum is extensively resected the thickened vomer removed or the anterior nasal spine sacrificed, the nasal bridge line may become concave, producing a false hump. With the consequent lowering of the tip of the nose the columella may retract. The deformity may be corrected by insertion of an L-shaped piece of sculptured cartilage fresh or preserved.

The *upper lateral cartilages*, the triangular cartilages, are two flat plates situated immediately below the free border of the nasal bones, spreading downward and outward from the septum with which they are directly continuous (Fig 1) They form the approximate middle third of the nose and are extremely important elements in the maintenance of normal contour in this location These upper lateral cartilages form the body of the nose and, with a hump, flare anteriorly (Fig 4) With a broad bridge, they are usually widened and flat, with saddling or a depressed bridge, they are sunken and deviated (Fig 5) Associated with an old hairlip, they may be flattened and depressed on the affected side



Fig 4—Elevation of the profile angle with essentially normal position of the tip of the nose The deformity is corrected by removing the hump to lower the profile angle, narrowing the nasal bridge and excising the medial margins of the upper lateral cartilages which flare anteriorly

The *lower lateral cartilages*, the alar cartilages, encircle the nostrils and assist in maintaining their patency Each cartilage consists of a medial and a lateral crus (Fig 1) The two medial crura approximate each other in the median plane, and, together with their investing soft tissues, form the lower part of the nasal septum, which, owing to its free mobility, is referred to as the *movable septum* Above, the medial crura are united to the septal cartilage, posteriorly, they end in free out-turned borders, anteriorly, they bend to form angles with the lateral crura The approximation of the two angles then forms the tip of the nose Sheehan⁴ has stated that of all the elements of the nasal framework, the one requiring the most delicate handling is the lateral extension of the alar cartilages The configuration of the nostrils is directly dependent upon the size, position, and contour of these cartilages

Columella—The character of the columella, be it long, short, narrow, or wide, will affect the shape of the nostrils Often an oblique columella will be

straight when more of the lower lateral cartilage is removed from either one side or the other. A retracted columella may be corrected in some instances by elevation of the tip of the nose (Fig 6). Other cases require the introduction of a supporting strut through a small separate incision (Fig 3). A hanging columella may be corrected by removal of a portion of skin from both



Fig 5—Saddle nose deformity possibly resulting from a childhood injury. In the developmental stage, extending through puberty the septal cartilage, through vertical upward pressure by the vomer below it, raises the dorsum of the nose. This explains the failure of the forward extension of the nose in disease or injury to the vomer occurring before puberty. This patient is unable to wear glasses because of the low nasal bridge line. Deformity was corrected in a single operation by inserting an L-shaped piece of sculptured preserved cartilage.

sides, or the utilization of the Aufricht procedure to correct the nasolabial angle (Fig 2). Occasionally surgery is required on the columella itself, such as a Z flap at the base or tip for the correction of an abnormally oblique one, or a V or Y incision at the base or tip for one especially short.

Arteries and Veins—The arterial supply to the nose is derived from the internal and external maxillary (branches of the external carotid) and from the ophthalmic, a branch of the internal carotid. These arteries terminate in capillary plexuses which supply the nasal mucosa, glands, and skin. The veins form a close cavernous network immediately beneath the mucous membrane. They anastomose freely and terminate in the anterior facial and ophthalmic veins.



FIG 6—A small hump associated with a retracted columella may be corrected by lowering the profile angle and elevating the tip of the nose. Greater care and caution must be exercised in correcting deformities of lesser degree than in those patients whose abnormalities are pronounced.

Nerves—The sensory nerve supply of the external nose is derived from (1) the infratrochlear, supplying the skin of the root, (2) the nasociliary branches of the ophthalmic, supplying the alae and tip, and (3) the infraorbital branch of the superior maxillary, supplying the sides. The only motor nerve of the nose is a branch of the facial which is distributed to the alar muscles.

Muscles—The muscles of the nose are vestigial. Immobilization following reduction of nasal fractures thus offers little difficulty, because there is no muscular pull that would tend to displace the fragments. The principal muscles of the external nose are the compressors and dilators of the nostrils and the depressors and elevators of the alae nasi.

PREOPERATIVE ANALYSIS OF DEFORMITY AND PLAN OF RECONSTRUCTION

Before attempting the correction of any nasal abnormality, it is paramount to have a clear mental picture of the final result to be achieved. In

disfigurement of the nose, there has been either loss of tissue or perhaps distortion of one or more of the component parts of the nasal framework from the position normally occupied in relation to one another or to the facial surroundings as a whole. In other instances, there may be both loss of tissue and malposition of the segments. Since noses are of infinite variety, contour, and configuration, it is imperative when planning the reconstruction, and most important during the execution of the repair, that the final result should be made to blend and harmonize with the configuration of the surrounding head and face of which the nose is the most important part. Because of the wide normal variation, the correct proportions of a given nose will for the most part depend upon the character of the structures which immediately surround it. The final judgment will be based on the operator's experience. The aim of reconstruction then is not to obtain perfect symmetry, but to bring an abnormality within the range of normal variation (Fig 7).



Fig 7—Webbing of the upper lip associated with a slight hump causes an optical illusion simulating a receding chin. The nasolabial angle is corrected by removing a small segment from the anterior border of the septum and the anterior nasal spine, and then using the Aufricht³ procedure to draw the lip back to normal position.

In addition to the proper technical approach, which in itself is a prerequisite, one must exercise a definite esthetic sense in deciding the extent of the desired change (Fig 8). Beyond the esthetic judgment, structural visualization of the anatomic architecture is likewise essential. While a thorough knowledge of the anatomy, physiology, and surgery of the nose is a *sine qua non*, the artistic creative power is the important factor in the success of the operation. Aufricht³ has said, "This esthetic sense can be developed with training and experience if there is an inborn foundation for it, if not, it is as futile as attempting to make a musician of one who is tone deaf."



Fig. 8—A long pointed nose with a small hump produces an unlightful deformity, corrected in a single operation. The artistic creative power is the important factor in the success of the rhinoplastic operation which may change the patient's entire facial appearance.

After establishment of the *esthetic diagnosis* of an abnormal nose, the next step is the study of the face and visualization of an improved substitute. A *photographic record* is most essential. (1) Slight abnormalities overlooked in the visual examination may immediately become apparent in the photographs. Photographs are useful not only in the study of the deformity, but also at the time of the operation, when contours are obscured by infiltration and edema. (2) Photographs are more easily and quickly comprehensible than a written description, and (3) are the best means of comparing pre- and postoperative conditions. (4) They also serve to remind the patient of the original appearance, which may be soon forgotten, (5) they may be indispensable for medico-legal purposes, and finally (6) they are invaluable for teaching purposes.



Fig 9—Casts of the face plaster wax, or lead, will assist in evaluating the deformity and planning the reconstruction. They are simple to make, inexpensive, and those of lead or other metal can be boiled at the time of operation. Beeswax or paraffin casts can be melted down and used repeatedly. One side of the plaster cast may be shaved down in hump noses or built up in saddle deformities and then accentuated with India ink, as illustrated.

A *plaster cast* or one made of wax will assist in evaluating the deformity and planning the reconstruction. One side of the cast may be sculptured or trimmed down to the desired level, in the presence of the patient, if this is desired. If there is a depression or saddling deformity, one side can be built up with modeling clay or one of the various plastic materials (Fig 9). A cast is especially important in planning the reconstruction of a receding chin.

Mechanical Devices for Measurement—To aid in reconstructing more accurately the nasal contour, Straith⁵ has devised a very useful profilometer. This ingenious measuring device has been most helpful in planning the transformation as well as in the execution of the operation, for it can be boiled with the instruments. Berson⁶ and Fomon⁷ have also developed measuring devices

Aufrecht³ has described a valuable procedure which, in addition to being very simple, is carried out directly on the skin of the nose at the time of the operation

OPERATIVE PROCEDURE

Preoperative Preparation—While the tissues of the nose possess marked local immunity and are very tolerant to contamination, it is also true that infection, when it does occur, is fraught with serious consequences. Aseptic principles must, therefore, be carefully observed. The vibrissae are clipped close and the vestibule is carefully and gently cleansed. The nostrils are quite tightly packed with one-half inch gauze packing which is moistened with 2.5 per cent pontocaine or 10 per cent cocaine and then wrung dry. This packing, preventing the escape of blood into the nasopharynx, is allowed to remain in place throughout the operation. Caution must be exercised in the use of cocaine, which is highly toxic and to which some individuals are extremely sensitive. Several drops of sterile mineral oil or castor oil are placed in the eyes, following which the routine preparation of the entire face is carried out and sterile drapes applied. The nose may now be marked with a 5 per cent alcoholic solution of brilliant green using the Aufrecht procedure³ or a Strath profilometer⁵ as a guide to determine the amount of correction necessary.

Local anesthesia is the method of choice. A solution of 2 per cent procaine to which has been added 10 drops of adrenalin per ounce is not only an excellent anesthetic agent but, in addition, is helpful in effecting hemostasis. Sites of injection are selected to anesthetize the infraorbital, infratrochlear, and nasociliary nerves. In those instances when local anesthesia is undesirable, endotracheal inhalation is the best method.

Smith,⁸ Safian,⁹ Sheehan,⁴ Brown,¹⁰ Fomon,⁷ and others have already described and illustrated the operative correction of various nasal deformities. Perhaps the most common type of nasal disfigurement is the long nose with a hump (Fig 10), and hence the correction of this type of deformity is described here.

Incision—The tip of the nose is elevated by engaging the alar rim with a small retractor held between the thumb and the index finger, while the middle finger exerts pressure on the outside of the nose, thus emphasizing the shelf between the lower end of the upper lateral cartilage and the superior border of the alar cartilage. Here a small intercartilaginous incision is made on each side, severing the aponeurosis connecting the two cartilages, and brought toward the midline to meet its counterpart (Fig 11, A). A long button-end scalpel is then introduced through one incision, carried over the dorsum until it appears through the opposite incision, at which point it is turned at right angles. It is then brought downward, curving around the anterior tip of the septal cartilage and hugging the inferior margin of the septal cartilage, to cut through the membranous septum almost to the nasal spine. The incision should not cut either the columellar cartilage or the septal cartilage but simply pass between them (Fig 11, B).

Undermining—The skin over the root of the nose and the adjacent parts is thin and loose and lends itself readily to plastic surgery. A small blunt

scissors, double-edged scissors, or scalpel is then introduced through the intercartilaginous incision and undermining effected superficial to the upper lateral cartilages—superiorly as far as the glabella and laterally as far as the nasofacial fold (Fig 11, C) No unsevered shreds of tissue should remain connecting the skin to the nasal framework beneath

Removal of the Hump In the step to remove the hump, a Straith pro filometer⁵ or the predetermined indelible marks suggested by Aufrecht³ will aid the operator in judging the amount of bone and cartilage to be removed A photograph or cast will also prove helpful (Fig 9) Using a periosteal elevator, the periosteum is pushed aside along the level at which the hump is to be removed If the septal attachment of the upper lateral cartilage is still intact, it may then be divided close to the septum with a straight scissors



Fig 10—The entire profile line is altered by corrective rhinoplastic surgery By preserving the glabellar angle and elevating the tip the chin is seemingly thrust forward, thereby removing the optical illusion of a receding chin.

The hump is then removed either with a saw or chisel Both require care and practice and neither possesses marked superiority A personal preference is a fine bayonet-shaped saw which is inserted through the original intercartilaginous incision and placed on the level of the normal profile The nasal bone is then sawed through carefully, severing the bony septum at the same level as the nasal bones (Fig 11, D, E) This same procedure is performed on the opposite side using the other saw

It will be found that the hump is still attached to the juncture of the nasal bone and the cartilaginous septum A blunt-pointed, straight-edged scalpel or an angulated knife is inserted under the severed bony hump and drawn downward and slightly forward to include a thin portion of the dorsum of the cartilaginous septum (Fig 11, F) The hump can then be withdrawn

with a pair of tissue forceps or a clamp (Fig 12, A) The somewhat rough and uneven edges of the bone are then smoothed off with a rasp introduced first through one and then through the other incision (Fig 12, B) Owing to its elasticity, the skin, if sufficiently undermined, adjusts itself to the newly shaped nasal framework no matter how large a section of bone has been removed

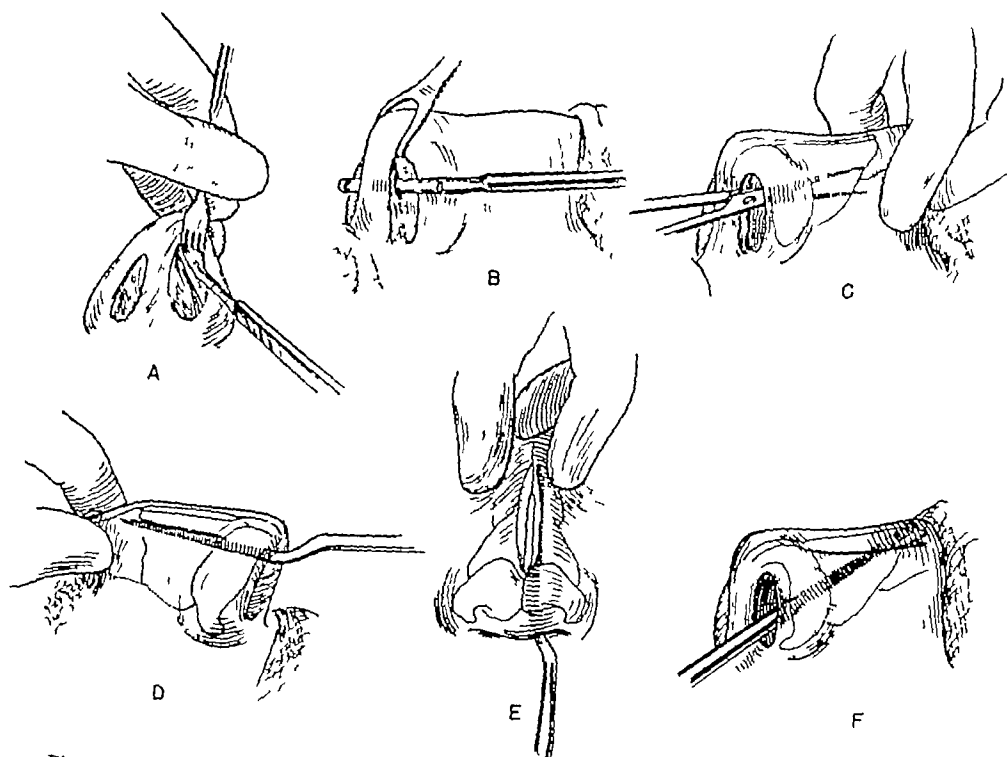


Fig 11—Technique of corrective rhinoplasty A, The tip of the nose is retracted and an incision is made between the upper and lower lateral cartilages severing the aponeurosis connecting the two cartilages. A similar incision is made on the opposite side. B A blunt-point scalpel introduced through one incision appears through the opposite incision and is then brought downward through the septum and columella to the nasal spine. C Skin is undermined laterally to nasolabial folds medially to the dorsum, and superiorly to the glabella. After elevating the periosteum a bayonet saw is introduced through the intercartilaginous incision to cut through the bony and cartilaginous elements (D, lateral view D dorsal view). After sawing through one side the other saw is inserted through the opposite side and the procedure repeated F, Button-end knife is introduced beneath severed bony section and drawn down to tip of nose completely freeing all elements

Narrowing of the Nasal Bridge—After removal of the hump, the excessive width of the bridge of the nose becomes markedly accentuated due to the gap between the resected edges of the nasal bones. For this reason, as emphasized by Safian,² Aufricht,³ and others, it is always necessary to narrow the nasal bridge, regardless of the smallness of the hump, in order to avoid a flat appearance of the dorsum from a frontal view. An incision is made in the vestibule at the nasofacial junction overlying the pyriform opening. The scalpel or scissors are carried upward toward the inner canthus separating the skin from the circumjacent structures. The periosteum along the proposed bone incision is displaced with a raspator. A right angle or bayonet saw, or a chisel, as recommended by Sheehan,⁴ is introduced subperiosteally in such

a manner as to permit the saw blade to rest upon the denuded frontal process of the superior maxilla flush with the face and with its point directed midway between the glabella and inner canthus (Fig 12, C) With the position of the saw maintained with the two fingers of the opposite hand, the bony process is sawed through with rapid strokes The same procedure is repeated on the opposite side, the operator being certain that the line of fracture on each side is in the same location The entire bony side of the nose may then be advanced toward the midline by exerting pressure with the thumbs, disrupting the attachment of the nasal bone to the frontal bone This *infracturing* technique of Joseph¹² (Fig 12, D) will have the effect of closing the gap between the resected edges of the bones and narrowing the bridge

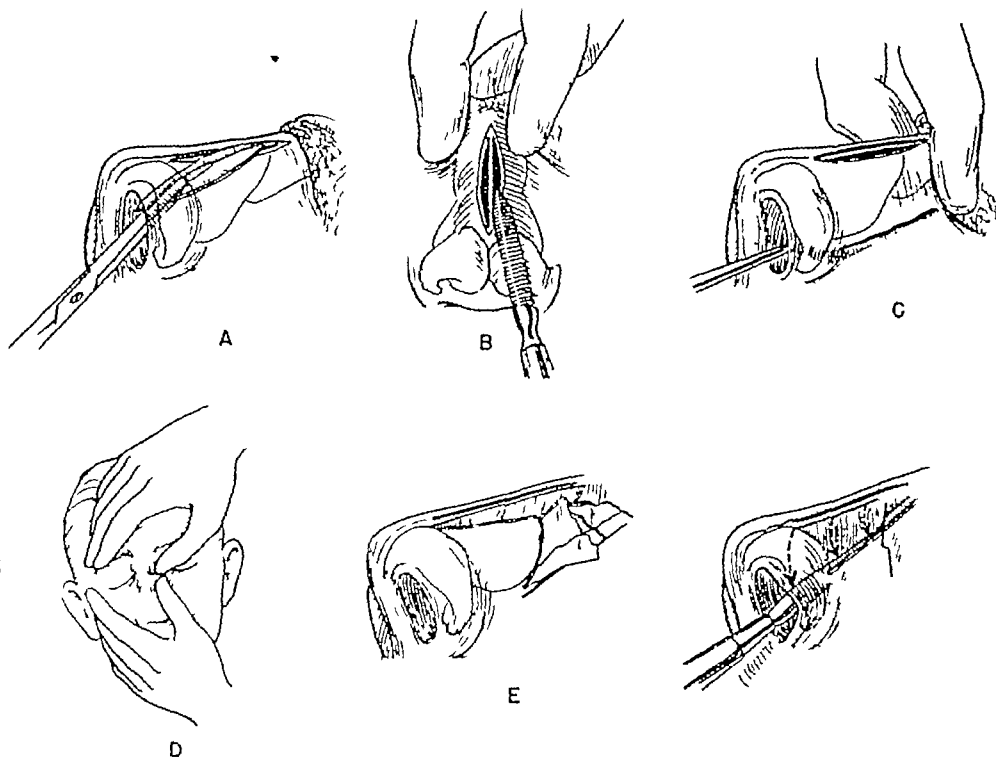


Fig 12—Technique of corrective rhinoplasty continued A, The hump is a clamp or forceps E, In palpating the skin of the dorsum, one notes the two cut edges of the nasal bone, one on each side, and the cartilage If these edges are rough or irregular they should be smoothed C, A small incision is made over the pyriform opening and a rasp is introduced to rest subperiosteally upon the denuded frontal process of the superior facial groove and the point directed midway between the glabella and inner of opposite hand protect the eye and maintain the position of the saw repeated on the opposite side D Nasal bones are mobilized toward midline pressure E, Typical comminuted fractures occurring with infracturing row the dorsum The radix nasi has not been fractured F Aufrecht's method A chisel is used to cut through the bony web of nasal bridge and radix downward and outward pressure the chisel levering from the frontal bone, ment is mobilized outward following which it can be pressed inward with a new line of the nasal arch.

Aufrecht,³ however, has found that quite frequently "the bony nose, instead of being fractured off or disarticulated in one piece from the frontal bone, will break somewhere in its upper third

a sharp spicule will remain firmly attached to the radix nasi. The bony side often breaks in more than one piece causing a comminuted fracture" (Fig 12, *E*). "The most disappointing experience, however, is that even after the bony sides have been completely disarticulated from their frontal attachment and have been pressed toward the center, the dorsum will still remain wide." This is explainable anatomically since the bony dorsum and the radix nasi are entirely different: the bony septum is thin and hollow, while the radix nasi is solid and massive. To correct this undesirable occurrence, Aufricht³ stated, "Instead of fracturing the nose inward from without, I fracture it in the reverse direction—outward from within. With 'outfracturing' there is less resistance to overcome, and there is more room for levering. Second, I divide the existing bony connection at the radix nasi. Third, I remove the bony web from within the dorsum, and a corresponding segment from the radix nasi when necessary."

In Aufricht's *outfracturing* technique the scissors, osteotome, or chisel is inserted close to the septum and with moderate force the remnant of the bridge and the radix nasi are cut through, then the bony side is moved outward, the chisel levering from the frontal bone (Fig 12, *F*). After being so mobilized, the bony sides can be pressed forward toward the midline with ease.

Reduction of a Wide Nasal Tip—Careful attention to details in remodeling the nose often determines the success or failure of the procedure. Large nostrils, flaring alae, bulging base of the nostrils, and improper direction of the alae are the most common shortcomings of the operation. As noted previously, Sheehan⁴ has emphasized the necessity for delicate handling of the lateral extension of the alar cartilages. The configuration of the nostrils is directly dependent upon the size, position, and contour of these cartilages.

In general, reduction in size of the alar cartilages, without greatly changing their form, may be accomplished with the method described by Safian.⁹ A short incision is made inside each alar rim close to the columella (Fig 13, *A*). The alar cartilage is then mobilized by undermining the subcutaneous tissue and the skin over it, as far superiorly as the original intercartilaginous incision, and laterally along the entire width of the cartilage. This undermining is nicely accomplished with a small pointed scissors. The mobilized alar cartilage is made to present in the vestibule and is severed with a scissors at its medial angle close to the columella (Fig 13, *B*). Removal of a section of cartilage and vestibular mucous membrane along the incised border will permit reduction in size and contour, equal to the combined width of the sections of cartilage excised. Lamont¹¹ does not disturb the nasal lining. The excised cartilage will have the shape of a hockey stick (Fig 13, *C*). This procedure has the effect of reducing the roundness of the nasal openings which usually accompanies excessive width of the alar cartilages (Figs 13, *D*, *E*, *F*). Elevating the tip of the nose will temporarily accentuate the roundness. While Safian¹³ believes that the alar cartilages should never be completely removed, Kitlowski¹⁴ frequently removes the alar cartilages in their entirety, without the shrinkage or pinched-tip effect which one might expect.

Shortening of the Nose, Elevation of the Tip—If the upper lateral cartilages have not already been severed from the septum, they are divided close to the septum in the intervening angle, but trimming is deferred until later. The soft tissues over the bridge of the nose are retracted upward, and the anterior end of the septum is made to present through the left nostril (Fig 14, A). Then, by judging from the predetermined measurements made at the beginning of the operation with the Straith⁵ profilometer or the Aufrecht³

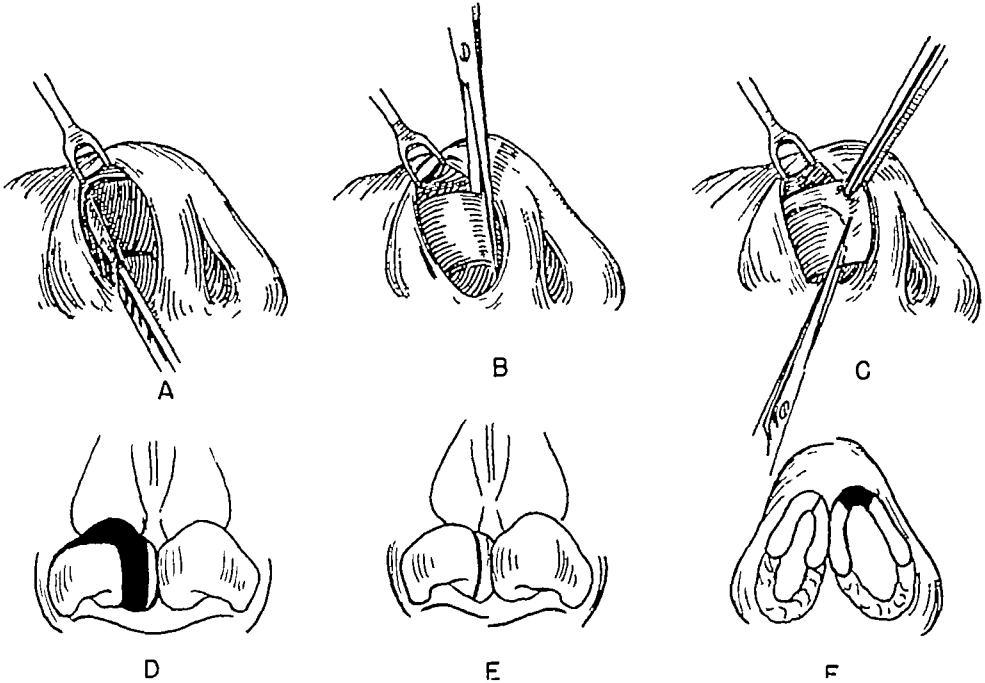


Fig 13—Technique of corrective rhinoplasty continued narrowing the tip of the nose. A, An incision is made along the lower border of the alar cartilage. The skin over the dorsal surface is undermined along the entire width of the cartilage. B, A small hooked retractor is inserted into the upper angle of the nostril and the alar cartilage made to present in the vestibule. The angle of the alar cartilage thus brought into view through the nostril is incised with a scissors along its width close to the septal margin. C, Removal of a hockey-stick shaped section of cartilage and nasal lining along the incised border will permit reduction in size and contour equal to the combined width of the sections of cartilage excised. This will also reduce the rotundity of the nasal openings which usually accompanies excessive width of the alar cartilages. D, Area of cartilage excised. E and F show effect of resection of alar cartilages superior and inferior views.

procedure, a triangular section of cartilage of a size sufficient to effect the required shortening is removed, the base of this triangle being directed upward and the apex toward the nasal spine. The tilt of the nose is governed by the size of the cartilage excised. The nose should be shortened to an extent somewhat less than the length of the chin line, but extreme conservatism should be practiced inasmuch as excessive shortening is not only unsightly, but may be difficult to correct. It is much better, when in doubt, to shave it down gradually and test to see when the desired elevation is obtained (Fig 14, B), rather than to remove too great an amount in a single section, and regret it.

Attachment of the Columella to the Septum, Trimming of the Triangular Cartilages—When the nose has been reduced and the alar cartilages altered, the columella is anchored to the septal cartilage with two medium silk sutures on Keith needles, one on each end of the thread (Fig 14, C) The needles pass through the entire thickness of both structures To compensate for the subsequent contraction, about 2 mm, inevitably taking place along the line of union, and the resulting drop of the tip of the nose of the same distance, the stitches should be placed obliquely so that when they are tied the tip will tilt slightly forward and upward (Fig 14, D) After the sutures are tied, it will then be found that the upper lateral cartilages, which are now too long for the shortened nose, protrude for a considerable distance into the vestibule Unless the redundant upper lateral cartilages are trimmed to correspond with the septal shortening, the lower half of the nose will appear unusually thick Therefore, both the medial and inferior margins are trimmed down so that the edges of the mucosa

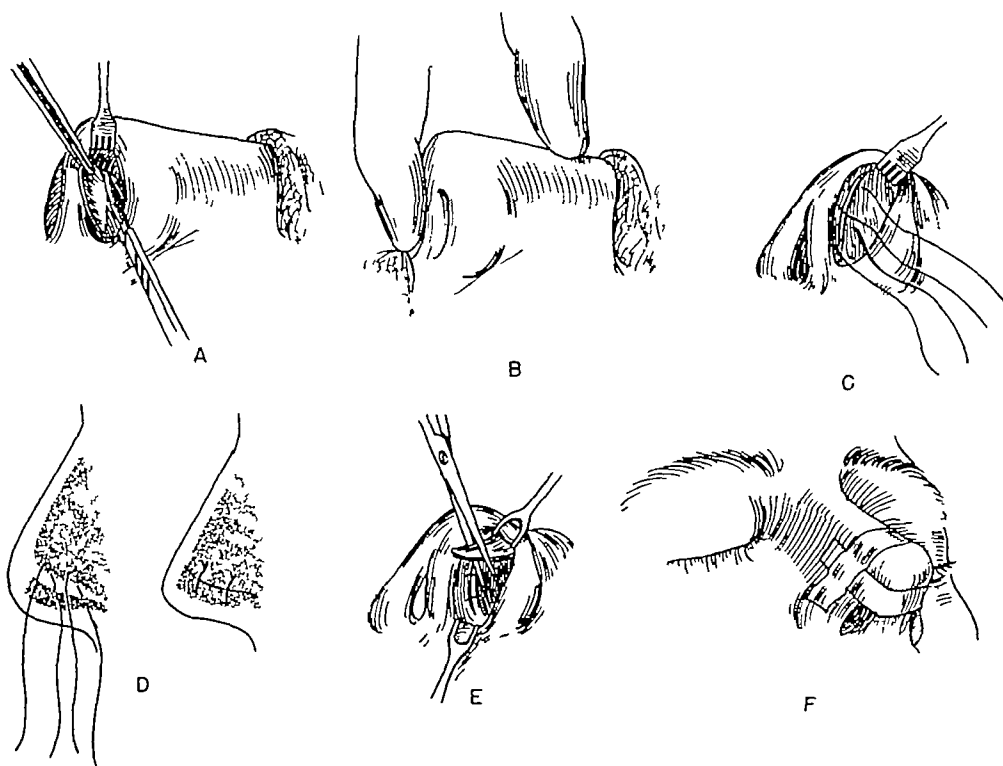


Fig 14—Technique of corrective rhinoplasty continued Shortening of the nose elevation of the tip A, A toothed forceps holds the septum rigid while the retractor holds the alar rim and columella out of the way The dotted line indicates the triangular segment of septum to be excised It is preferable to shave it down gradually and test to see when the desired elevation is obtained (B) rather than to remove too much and produce an excessive shortening C, The columella is reattached to the septal cartilage by two medium silk sutures The tip of the nose may be raised or lowered with these sutures D To raise the tip the through-and-through sutures are inserted so that they pass through a more anterior point in the fixed septum than in the columella The threads are tied so that the columella and the tip of the nose advanced forward and the sutures extend vertically across the incision E The redundant upper lateral cartilages are trimmed to correspond with the shortening of the septum F, New position of lower lateral cartilages maintained with adhesive or cellophane tape Splint, stent, or brace is then applied

are again in apposition (Fig 14, *E*) Since the edges of the intercartilaginous incisions fall into apposition, they may be left without sutures if desired

Dressing and Immobilization—After compressing the nose from above downward to expel blood and clots, the intranasal packs are removed and the nostrils may be packed again lightly with a grease-impregnated gauze Although the nasal muscles are vestigial and not capable of causing displacement of the parts, it is still desirable to immobilize the nose for the first forty-eight hours, not only to offset the possibility of accidental disturbance of the fragments, but, in addition, to reduce swelling and discoloration Various methods of immobilization have been described, all of which are simple and satisfactory the dental stent recommended by Aufrecht,¹⁵ the metal splints used by Blair and Brown,¹ the small brace designed by Safian,⁹ or straps of adhesive tape without other support as used by Lamont¹¹ (Fig 14, *F*) The splint or brace is allowed to remain for two days, the nostrils cleansed, and, if desired, the adhesive straps and brace may be reapplied

Following nasal reconstruction, most patients have very little discomfort and are ready for discharge in about one week The columellar-septal sutures should remain for at least one week Each patient is told in advance that he will develop "two black eyes" and can thus adjust his professional or social calendar accordingly, for in some instances the ecchymosis will not completely disappear for two or more weeks

CONCLUSION

Because of the natural prominence of the nose, any nasal deformity is conspicuous and frequently is the only blemish of an otherwise pleasing face The reconstruction of the defects by those properly trained and qualified offers very little difficulty for the patient and, properly performed, will in a great many instances result in a greatly improved general appearance The psychic importance of reconstructive surgery of the nose has been emphasized A comparatively simple operation, performed under local anesthesia, often relieves the patient of a deformity which has been the source of mental anguish and anxiety Although a face may or may not be a fortune, the importance of its appearance receives the greatest emphasis when the face or nose happens to be a misfortune The counsel of "patient resignation" too often given by physicians and friends is unkind and unsound in the light of surgical achievements in plastic surgery Some of these have been presented

The author is indebted to Dr Joseph Beard and Miss Frances Powe for advice and assistance in the preparation of the manuscript to Mr Norrie Parkes and Mr Robert Little of the Department of Medical Illustration for the drawings and photographs

REFERENCES

- 1 Blair, V P, and Brown, J B Nasal Abnormalities, Fancied and Real, Surg, Gynec & Obst 53 797, 1931
- 2 Gillies, H. D The Development and Scope of Plastic Surgery, Bull Northwestern Univ Med School 35 1, 1935
- 3 Aufrecht, G A Few Hints and Surgical Details in Rhinoplasty, Laryngoscope 53 317, 1943
- 4 Sheehan, J E Plastic Surgery of the Nose, New York, 1936, Paul B Hoeber, Inc.
- 5 Straith, C L Reconstruction About the Nasal Tip, Am J Surg 43 223, 1939

- 6 Berson, M. I Important Considerations in Rhinoplastic Procedures, Eye, Ear, Nose & Throat Monthly 22 424, 1943
- 7 Fomon, S Surgery of Injury and Plastic Repair, Baltimore, 1939, Wilhams & Wilkins Company
- 8 Smith, F Reconstructive Surgery of the Head and Neck, Nelson's Loose Leaf System, New York, Thos Nelson & Sons, also, Manual of Standard Practice of Plastic and Maxillofacial Surgery, Military Surgical Manuals, Philadelphia, 1942, W B Saunders Company
- 9 Safian, J Corrective Rhinoplastic Surgery, New York, 1935, Paul B Hoeber, Inc
- 10 Brown, J B Reconstructive Surgery of the Nose, chap 2, vol 8, Nelson's Loose Leaf Surgery, 1940, New York, Thos Nelson & Sons, p 237
- 11 Lamont, E S Reconstructive Surgery of the Nose in Congenital Deformity, Injuries and Disease, Am J Surg 65 17, 1944.
- 12 Joseph, J Nasenplastik und sonstige Gesichtsplastik, Leipzig, 1931, Curt Kabitzsch
- 13 Safian, J Failures in Rhinoplastic Surgery, Am J Surg 50 272, 1940
- 14 Kitlowska, E Personal communication
- 15 Aufrecht, G Dental Molding Compound Cast and Adhesive Molding in Rhinoplastic Surgery, Arch Otolaryng 32 333, 1940
- 16 Aufrecht, A Combined Nasal Plastic and Chin Plastic, Am J Surg 25 292, 1934

Book Reviews

Pneumoperitoneum Treatment. By A L Banyai, MD, F A C P, pp 376, with 74 illustrations, St Louis, 1946, The C V Mosby Company

The author of this monograph is most qualified by the duration and extent of his experience to write on this subject. He contributes a valuable reference book on the basis of his own experience and an exhaustive coverage of the world literature. The bibliography lists almost 700 references, including 24 of his own contributions to the use of pneumoperitoneum. Everything pertaining to this method of treatment is included in the text and the references. The chapter devoted to the technique of administration will be found valuable. Less than one-half of the text discusses the technique and application of pneumoperitoneum to the treatment of pulmonary tuberculosis while the remainder covers its possible application to ten other conditions in which its utility at best is doubtful. The discussion of physiologic changes has some statements of questionable validity with regard to the subdiaphragmatic pressures. The numerous illustrations are roentgenograms which show the gross effects of pneumoperitoneum adequately. On the whole, this book includes so much material with so little critical evaluation that it should be read with the thought in mind that pneumoperitoneum is still under trial as a method of treatment and can at most be only supplementary to other methods which either treat the whole patient or attack the problem of pulmonary disease and infection more directly.

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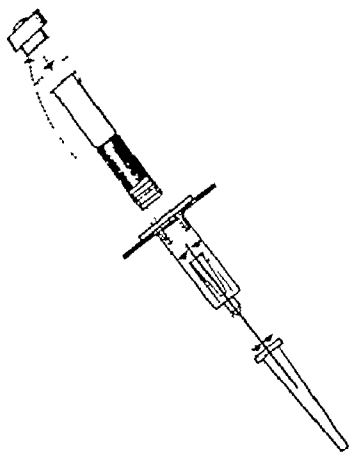
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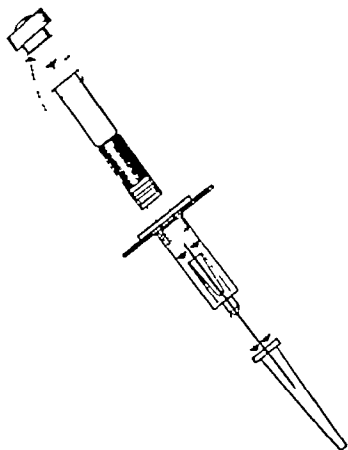
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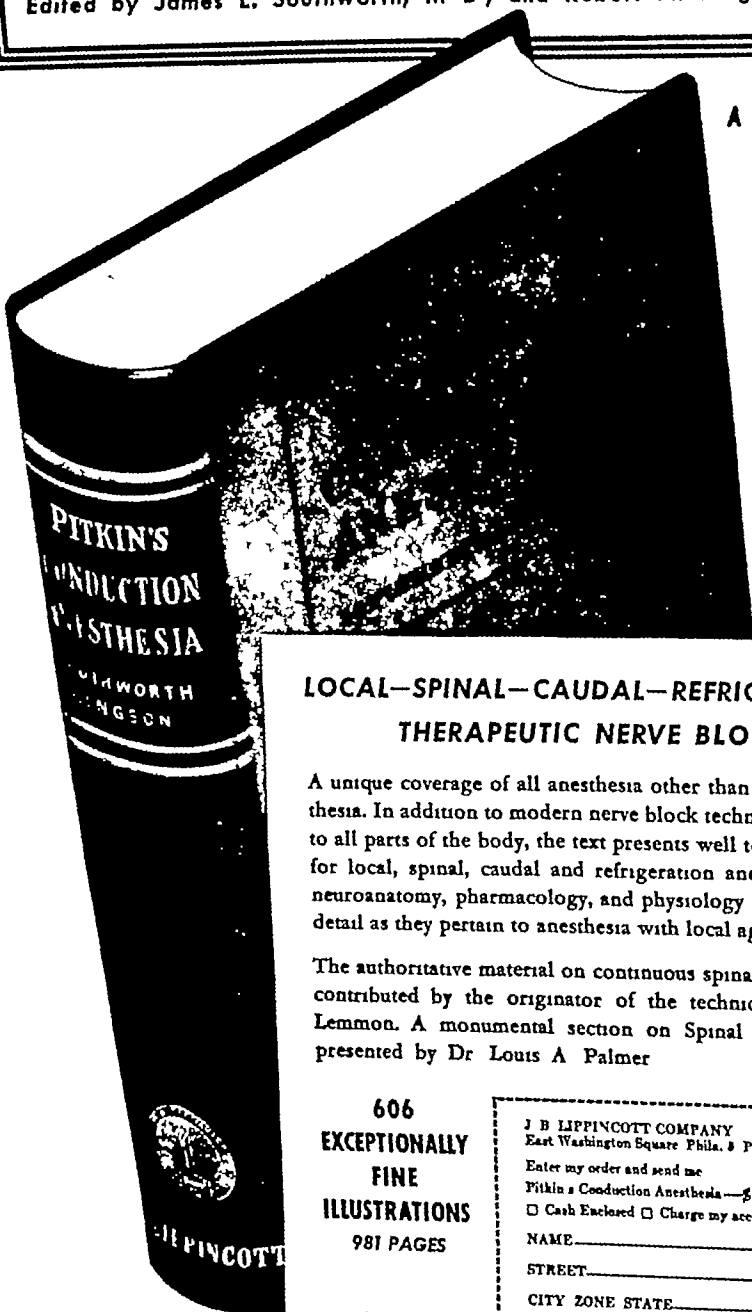
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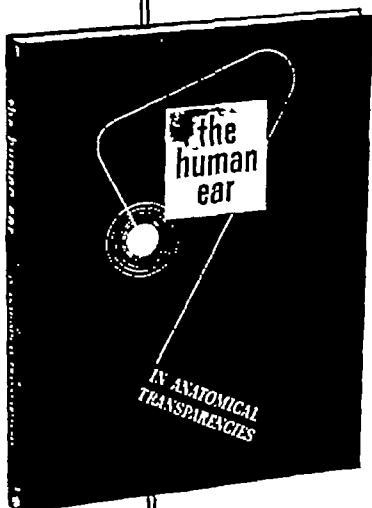
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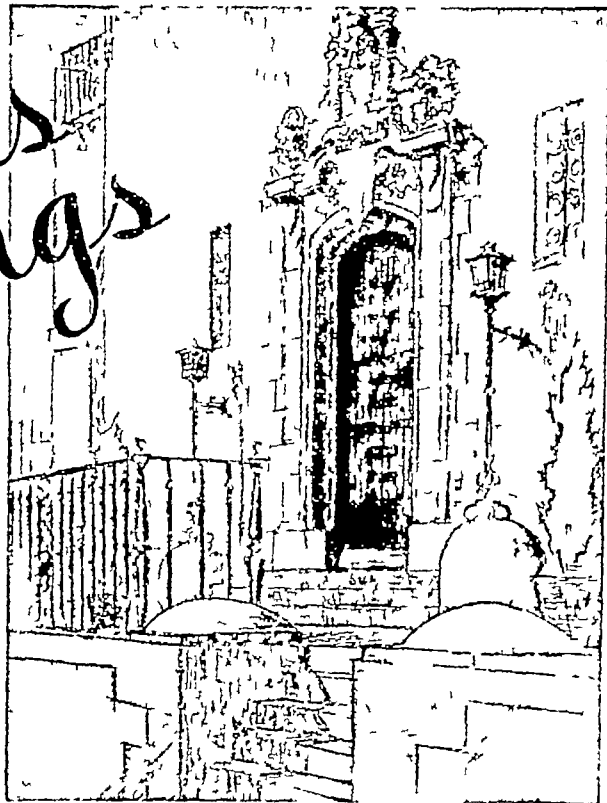
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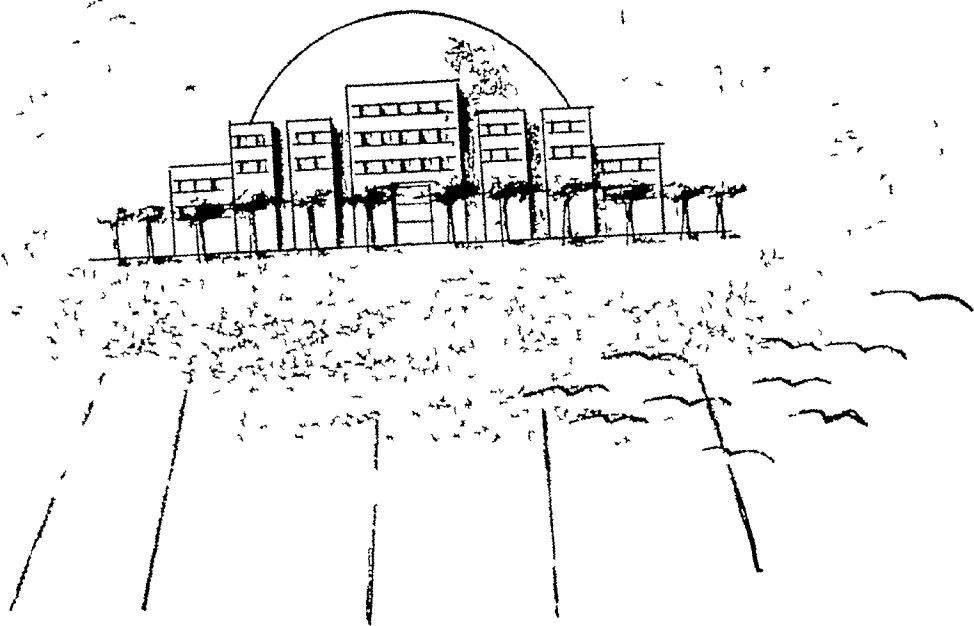
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